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For Editorial Contents see page 251

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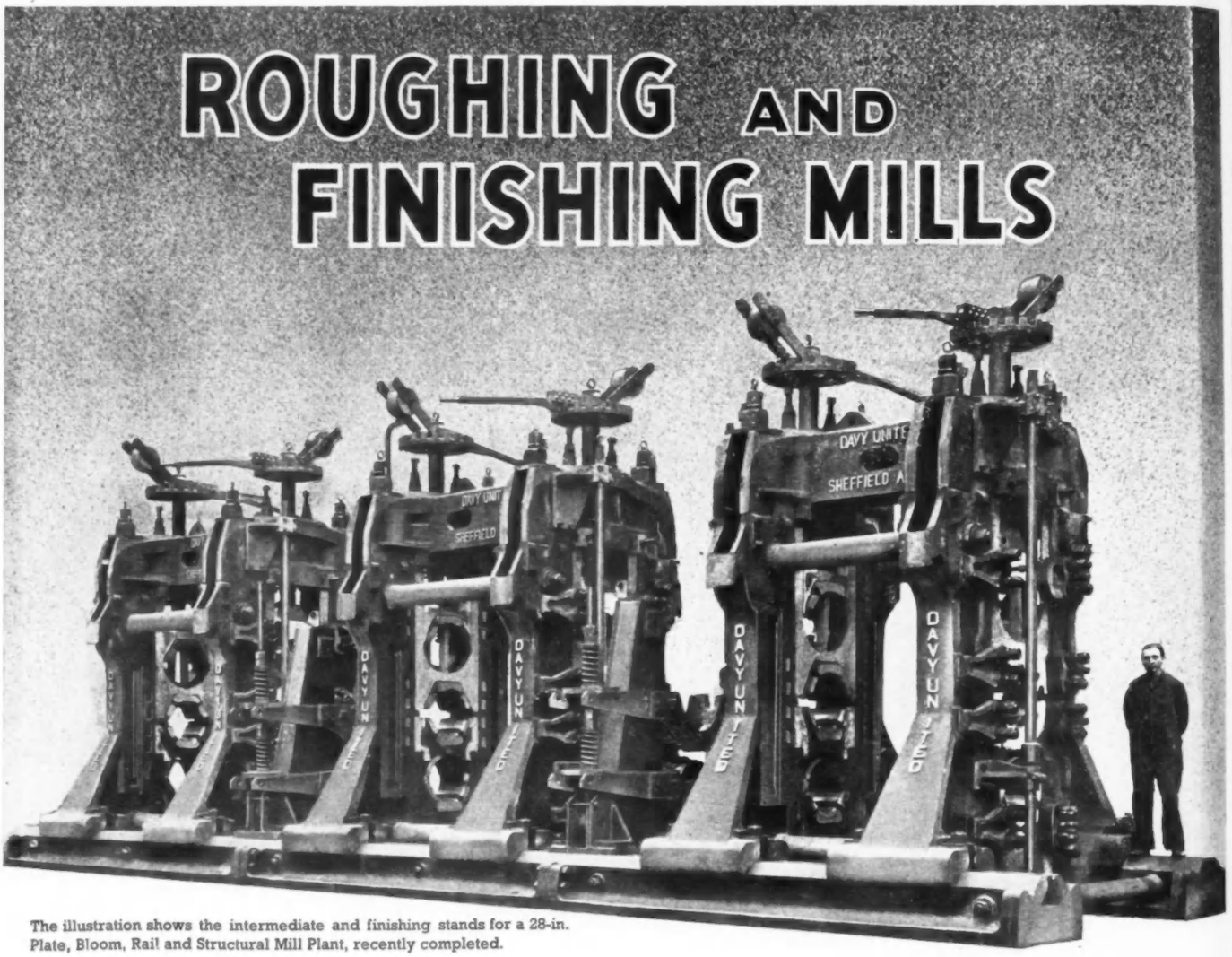

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CLAY AND SOIL MECHANICS.

By R. R. MINIKIN.

THERE are few subjects in civil engineering which have aroused so much interest in recent years as the erratic behaviour of clay, the properties of which give rise to many troublesome problems. In spite of the considerable help given by mathematicians and research experts in the solution of practical difficulties there still remains much to be done in the field to arrive at satisfactory conclusions, as Dr. Stradling has pointed out. The peculiar structure of clay and its great affinity for water react in such a complicated variety of ways that definite causes of instability are frequently untraceable. It is only in the latter years that it has been appreciated that the presence of bound water in the clay is the primary cause of its vagaries. The physical constituents also play their parts, though some divergence of opinion on this matter has been expressed in professional circles. When one is called upon to deal with clay slips of hundreds of thousands of tons it is perhaps excusable, if not scientific, to disregard the ionic nature of the material of the mass, but the amazing thing about clay is that those very minute less-than-particles influence the movements of the whole mass.

Clay in its undisturbed state has a complex cellular microstructure, the larger silt grains being separated by smaller clay particles and yet smaller flocculated colloidal particles. The colloids are of two orders: one, in direct contact with the silt grains, is under a high degree of consolidation, while the other, lying in the zones between the silt grains, is under a lesser degree of consolidation. This arrangement is shown in Fig. 1. The very minute interstices or voids between the colloids hold the water by capillary attraction and give rise to the characteristic nature of the clay. These voids are highly retentive and a considerable external pressure is required to expel the water. Thus, in spite of its appearance, a block of clay is not solid; the proportion, by volume, of the voids and solids, however, varies with different clays. This proportion is spoken of as the "void ratio" and ranges from 0·33 in hard clays to 2·5 when clay is almost liquid. Arising from this, some eminent authorities describe clay as "a solid of colloidal particles of friable insoluble rock-forming minerals and water." The human eye cannot recognise the colloidal particles, but it can appreciate their existence. If a filtrate of clay solution, in a beaker, is examined under a strong light, the water will show an opalescence caused by these very small particles. Although the latter are larger than molecules they are not visible under a microscope. They range from 10^{-4} cm. to 10^{-6} cm. in diameter.

Clay is not an inert material but has a degree of mobility proportional to the percentage content of bound water; under pressure it acts as a highly viscous liquid. One of the most peculiar characteristics is its quality of cohesion under varying conditions. It is well known that colloids have a great attraction one for the other and clay is no exception. When a lump of clay is dried out by artificial means it does not fall apart. If this same lump of clay were contained in a closely fitting vessel and then immersed in water it would greedily absorb an appreciable quantity. In doing so it would swell and exert a considerable pressure on the vessel. Pressures of the intensity of 10 tons per sq. ft. have been measured in such experiments. On the other hand, drying by artificial means causes it to contract, exerting a tensile force of 2½ tons per sq. ft.

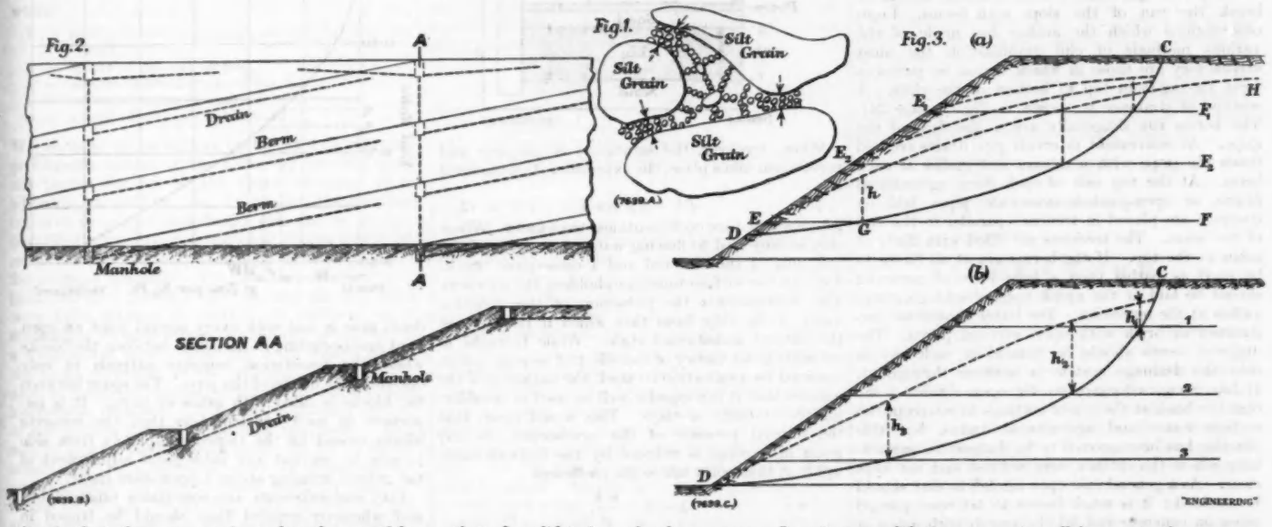
In solids the molecular pressure is the cause of cohesion but in the complex structure of clay the capillary action in the minute pores assists the colloidal attraction considerably. This fact is most pronounced when the clay is subjected to external pressure causing a reduction of volume, which, in effect, is a reduction of the void ratio and a consolidation of the original specimen. For soft metals, Poisson's ratio is about 0·26 but this ratio is also applicable to clay; and the elasticity modulus of clay bears the same relation to the capillary pressure as that of a solid to its molecular pressure. In spite of the fact that clay may be reduced so easily to the consistency of a cream or slurry, a dried block of the same material may show a tensile strength of about 250 lb. per sq. in. and an ultimate compressive strength of ½ ton per sq. in. Such extraordinary properties in a material that may be an apparent solid at one moment and at another, by mere mechanical contact with water, become a semi-liquid is an indication of structural unreliability.

In most offices and engineering handbooks a value of 30 deg. to 45 deg. is given as the angle of repose for clay. This is misleading; clay has no angle of repose, as generally understood. An illuminating example is that given many years ago by Mr. Mitchell Moncrieff, in connection with a cutting through a "beautiful uniform blue clay" in Norway. The cutting was about 110 ft. deep and ran east and west. The north bank therefore had what sun there was and the south bank remained in shadow. On the former several temporary walls of clay 20 ft. high surcharged with slopes of 1 vertical to 1½ horizontal stood perfectly for months while on the south bank the clay "ran like porridge." Such contradictory phenomena, of which many similar examples could be given, have resulted in creating a belief that the behaviour of all clays is indeterminate. This, however, is not so.

In spite of the present inability of engineers and technicians to postulate in simple form the laws that govern the behaviour of clays, there are means for determining, even over a period of time, the behaviour of particular clays in the natural state, where the conditions are known. Under the efficient guidance of Terzaghi, Casagrande and Gilboy, many engineers and scientists have contributed to found the new science of soil mechanics which includes the intensive study of clays. Many of the contributions are not spectacular but are definite practical links in the chain. It will be appreciated that the shape of the particles composing the mass of clay will have a considerable influence on the behaviour under certain conditions. Thus the mobility of a clay is due to the penetration of water between the flaky particles or metallic ions forming the unit cell of the clay molecule. Clay is spoken of as impermeable, but this is only relatively true. Water does flow through clay, even if slowly, when it is subjected to pressure. This fact provides the basis for the soil mechanics theory of settlement.

One of the outstanding characteristics of clay is that it loses a considerable amount of what stable properties it possesses when it is disturbed or exposed to weather in its original position. It is therefore most difficult to apply mathematical treatment to a disturbed clay, whether such clay be in embankment, cutting, or fill: in colloquial language it has undergone, as a material, a severe surgical operation and requires prolonged rest before it can regain its former properties in the natural state. This disturbed state may even take the form of an over consolidation, or, as is well known to those accustomed to work with clay, the exposed surfaces of a freshly cut clay may change rapidly to a material of different properties to the undisturbed original. It may be found that clay from a cutting 100 ft. deep when tipped in an embankment 50 ft. in height will not even bear its own weight. In this connection the method of excavation plays an important part. It is common experience that the smaller the lumps of clay tipped are, the better the consolidation; in other words the spoil from spade or drag-line is preferable to that from a steam digger for embankments.

During dry weather the exposed surface of clay dries out. In effect, this reduces the cohesion, or rather the apparent cohesion, for the real shearing cohesion of clay is very small. The greater part of the apparent cohesion, is due to the surface tension of the water held by the capillaries. Where extensive surface cracks form consequent upon the shrinkage in drying out it will be appreciated that not only is the shearing resistance destroyed for the extent of the crack but the shearing resistance of the dried clay itself is reduced. In addition, the diminished surface area of the section including the crack is subjected to an increase of stress intensity. If this takes place in an embankment, cutting or cliff, slip may not occur immediately, but the ground is in a condition to precipitate it on the first fall of rain. On the other hand, the most extensive slips take place during or shortly after very wet weather when the ground is saturated. Typical examples of this form of slip occur in natural clay cliffs such as those at Frinton, Herne Bay and Folkestone. There



it can be noticed that the fracture of the top surface is mainly curved in plan and the ground swept out by the slip takes the form of a miniature valley. Frequently a succession of these valleys occurs giving in plan view a series of cycloidal or semi-circular curves at the cliff top. It has been assumed sometimes that the shoulders left standing between these slips are of a more stable nature but this assumption has been proved to be inaccurate. It is more likely that the shoulders are an indication that the slip is due to local saturation, whereas slips of greater extent in which the shoulders or spurs are not formed would indicate the existence of incoming water over the area. The semi-circular form of rupture is explained by the fact that it is that shape which offers least surface shearing resistance for the volume of material slipping. Immediately after such a slip the standing spurs become self draining and are thus relieved of the hydrodynamic head which caused the slip.

To stabilise the slopes of clay cliffs the chief necessity is a thorough drainage system. This may mean drainage of incoming water well back from the cliff face. The slope should be drained by a main pipe drainage system with intermediate rubble drains in "chevron" or "herring bone" pattern. The average slope of the cliff should be trimmed to 1 vertical to 2½ horizontal. It is an advantage to break the run of the slope with berms. From observations which the author has made of the various methods of cliff stabilisation the most satisfactory are those in which berms in pathway form zig-zag from top to bottom of the cliffs. A method of drainage is shown in Fig. 2, page 241. The berms run diagonally across the face of the slope. At convenient intervals pipe drains are laid down the slope with manholes and gullies at each berm. At the top side of each berm agricultural drains or open-jointed stoneware pipes laid on concrete are placed in trenches parallel to the run of the berm. The trenches are filled with flints or ashes to the top. If the berms are at all likely to be used as paths, then a light form of guttering should be laid at the uphill verge discharging into gullies at the manholes. The latter should be constructed in brick with open vertical joints. The diagonal berms should be parallel in each bay so that the drainage system is uniform throughout. It has been customary to dig open ditches some distance back at the top of cuttings to intercept the surface water and agricultural drains, but this practice has been proved to be dangerous, particularly where the ditches were unlined and not kept clear. As a general rule open ditches in clay should be avoided; it is much better to lay open-jointed pipes on concrete and fill the trench with ashes or flints. Broken stone, brick or clinker are not so good, as the interstices choke more rapidly.

A probable seepage path of water through the ground of a saturated slope is shown at C D, Fig. 3 (*a*), page 341. Along a plane E, F the hydrodynamic head of the seepage water varies as shown by the dotted curve E, H. Where the path of water C, D crosses the plane E, F at G, the hydrodynamic head at that point will therefore be h. If then at different heights of the slope curves of hydrodynamic head along the respective planes are plotted it will be possible to find the value of the hydrodynamic head of water of any seepage path which cuts these planes. Thus in Fig. 3 (*b*) on the planes 1, 2 and 3, the respective ordinates h_1, h_2 and h_3 of the hydrodynamic head on the seepage path at the level of the planes are erected. A line shown dotted is then drawn through the points. Then the vertical ordinate at any point between the dotted curve and the seepage path C, D will represent the hydrodynamic head at that point. Thus it will be seen that in wet weather self-draining ground is subjected to internal hydraulic forces which may dangerously affect the stability. As Professor Terzaghi has pointed out, this action takes effect in a reduction of the shearing resistance of the ground. The well known experiments of A. L. Bell proved conclusively that the intensity of shear resistance of a coherent soil in partial saturation is

$$k + p \tan \alpha, \quad . \quad . \quad . \quad (1)$$

where

k = coefficient of cohesion,
p = normal pressure intensity per unit area, and
α = angle of internal friction.

CLAY AND SOIL MECHANICS.

Fig. 4.

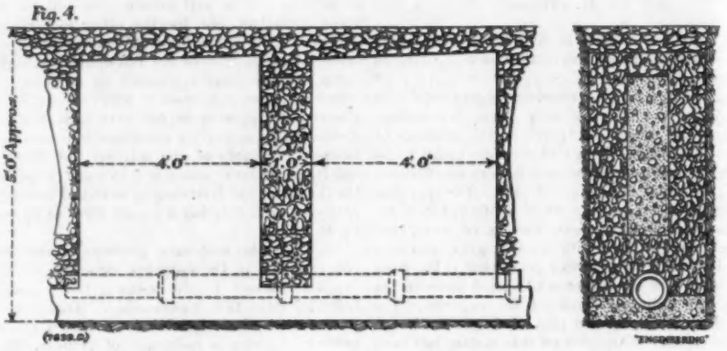
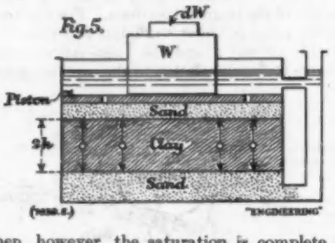


Fig. 5.



When, however, the saturation is complete and percolation takes place, the expression (1) is modified to

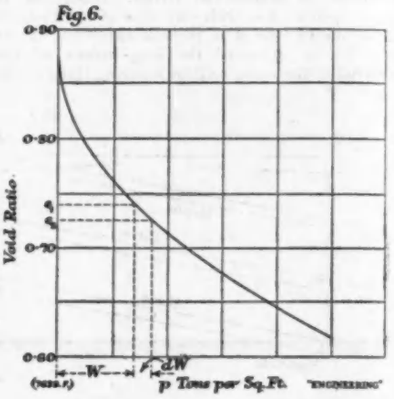
$$\psi k + \lambda p \tan \alpha \, . \quad . \quad . \quad (2)$$

where ψ and λ are coefficients less than unity. Where clay is subjected to flowing water there is a definite softening of the material and a consequent breakdown of the surface tension upholding the cohesion. The ψ represents the reduction of the cohesion value of the clay from that which it possesses in the natural undisturbed state. While Terzaghi, in submitting his theory of the effect of seepage water, confined its application to sand, the author is of the opinion that it can equally well be used in considering the stability of clays. This would mean that the normal pressure of the overburden on any point in a plane is reduced by the hydrodynamic uplift at that point where the coefficient

$$\lambda = 1 - \frac{w h}{p}.$$

Apart from the effects of weathering on clays, there is a clay group which has certain inherent weaknesses. The low water-content clays, or those which have almost reached the plastic limit, are often fissured in the mass. Where such fissures are near any excavation, not only will the shearing resistance of the section be reduced but the clay relieved of the side pressure will expand laterally and a slip may result, even in dry weather. There would also appear to be an age limit to the stability of a slope. Many engineers have encountered slips in cuttings which, originally well designed and constructed, have, after the lapse of several decades, shown unstable symptoms without any traceable outside influence. It is possible that this type of slip may be due to a prolonged swelling of the clay and the slow gradual percolation of water into internal cracks and fissures. The general solution to such problems is to preserve the shearing resistance of the section. This is best effected by a thorough scheme of drainage and an adequate surface protection. The latter may take the form of a blanketing of sand or fine ashes about 8 in. to 12 in. deep over the surface of the slope or a layer of good top soil and closely knit turf. In wet clays it is sometimes found that there is a tendency for the toe of the slope to creep forward and force the base of a cutting upwards. To counteract this a sunken toe wall with combined drain, in addition to the slope drainage, has been found effective—see Fig. 4. The toe wall is formed of concrete blocks cast *in situ* about 4 ft. by 2 ft. 6 in. by 5 ft. deep and spaced 1 ft. apart. The foundation of the blocks is continuous, and on it a stoneware

Fig. 6.



drain pipe is laid with every second joint an open joint and occurring in the space between the blocks where the foundation concrete extends to only one-third the height of the pipe. The space between the blocks is filled with ashes or flints. It is important in such constructions that the concrete blocks should fill the trench completely from side to side to prevent any subsequent adjustment of the ground bringing about a premature shear.

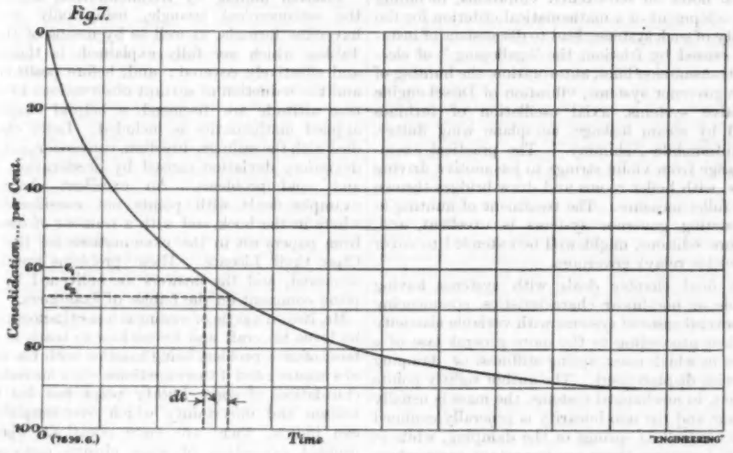
Clay embankments are sometimes unavoidable, and whenever erected they should be tipped in small lumps. All large lumps should be broken up. In wet weather, construction should be held up, and a too dry clay should never be used. The tipping should progress in layers of from 5 ft. to 8 ft. deep and be consolidated with a cambered top. A rise of one-twelfth to one-twentieth of the width is suitable. On this cambered plain surface a layer of 8 in. to 12 in. of ashes or sand should be spread with a level top and well consolidated. It is important that the consolidation should not be excessive, as subsequently in wet weather the clay may expand and defeat the object of the original compaction. On the ash layer the successive layers of clay and ashes are laid in a similar manner to the full height. Slopes of 1 in 2 to 1 in 3 are suitable. On the steeper slopes the top surface should be covered with at least 6 in. of sand or ashes; less than this is useless, as rain then penetrates too easily. Where the foundations are weak it is advisable to provide a substantial berm at about half the height and, if possible, to strengthen the toe with hard-core laid in a shallow trench. The usual precautions must be taken for thorough drainage of the crown and toes.

The various formulæ for earth pressure against lateral supports must be used with caution where the back fill is clay or a clayey soil. The principal difficulty in all formulæ, with the exception of that of A. L. Bell, is the assumed angle of repose. If the backing of a wall is undisturbed strata and is reasonably protected and drained of excess water, then Bell's formula is the most suitable:—

$$P = \frac{w h^2}{2} \tan^2 \left(\frac{\pi}{4} - \frac{\alpha}{2} \right) - 2k \tan \left(\frac{\pi}{4} - \frac{\alpha}{2} \right). \quad (3)$$

CLAY AND SOIL MECHANICS.

Fig. 7.



where

P = resultant active pressure on the back of the wall,
h = height of the wall in feet.
α = internal friction angle of the clay,
k = cohesion constant, and
w = weight of clay per cubic foot.

Where, however, a wall is backfilled with clay the problematic nature of the disturbed material does not permit the use of the above formula. It is advisable in such a case to neglect the original cohesive properties and design the wall as though backfilled with granular material of low angle of repose, unless special precautions have been taken for efficient drainage. The ordinary method of a hard-core strip between the wall and the clay with weep holes through the wall is not sufficient, as it encourages seepage across the fill and gives rise to a hydrostatic head within the mass which lowers the shear resistance of the material. It is preferable to promote vertical drainage to reduce this hydrostatic pressure. To do this, a planned system of sub-surface drains is the best safeguard. This will be greatly assisted by tipping the fill in layers interlarded with ashes or sand as described for embankments. If this is done, then an angle of repose of 30 deg. to 35 deg. may be used in the customary formulæ for the newly-placed backfill. With the lapse of time, providing the drainage prevents the holding of any excess water and the surface protection prevents a too severe drying out in fine weather, the backfill may consolidate to such an extent that cohesion may be in part restored. As a result, the actual thrust on the retaining wall will be considerably reduced.

The problems of clay in the undisturbed condition can be fairly readily resolved by mathematical treatment, particularly those concerned with foundations. The clay stratum may be at a considerable depth below the footings of a building. Research shows that a clay stratum at a depth equal to 1½ times the width of a building is affected by the weight of the building and in many cases the effects are evidenced at the surface of the ground by settlement. Settlement within reasonable limits is not in itself a structural danger providing it is approximately uniform, and it is a decided advantage from all points of view to be able to predict the probable dimensional extent and the time it may take to reach vertical stability. It is the aim of soil mechanics to evaluate these factors of stability.

If a material carrying bound water, such as clay, is subjected to pressure under water, the hydrostatic pressure in the capillaries is increased. The water is therefore squeezed out and the clay particles brought closer together; there is a consolidation or reduction of void volume. The pressure employed on the clay is a measure of the resistance to the flow of the capillary water. This flow has been found by experiment in specially constructed apparatus to be a function of time, porosity and particle size. The two latter qualities are also a measure of the permeability of the clay. To this D'Arcy's law of filtration is applicable :—

$$V = k A t \frac{h}{l} \quad . \quad . \quad . \quad (4)$$

where

V = volume of filtered water,
A = area of the surface of the filter,
k = co-efficient of permeability of the filter material,
t = time, and
$\frac{h}{l}$ = hydraulic gradient.

Clay has a low permeability and therefore the freeing of the capillary water will be slow. In capillaries of less than 0·00001 cm. the permeability is exceedingly small. A further feature peculiar to clays is that there is a decrease of porosity in the stressed material and hence a continuous increase of the time rate to expel the bound water before complete consolidation is reached.

The principle of the test apparatus is shown in Fig. 5, opposite. A block of clay $2h$ thick is sandwiched between two layers of sand (porous stones are actually used), closely fitting a vessel filled with water. On the top sand layer a finely perforated piston is placed; assume this to be weightless and the sand and water to be incompressible. If now a weight W is placed on the piston the clay will be compressed and there will be a consequent hydrostatic pressure in the pore water, which will tend to squeeze the water out of the clay and bring the particles closer together. If this pressure were to be applied in the dry state without a containing vessel, the surface tension in the pores would prevent the flow and the clay would be distorted without suffering change of volume. For this reason, and to approximate more closely to natural conditions, the clay is immersed in water. This ensures that the resistance is limited to that of a viscous fluid travelling by the shortest path in the minute pores to the free surface of the clay. As will be shown later, the mathematical theory is based on this condition.

The applied load W, which is adjusted to the equivalent intensity of the overburden pressure in the natural state, will bring about a partial consolidation representative of the condition of the stratum in the field. The addition of any further load will cause an increased consolidation. If this proceeds in increments of dW until equilibrium density is reached, the void ratio for each respective increment of load can be recorded and a graph plotted, as shown in Fig. 6, the volume of the expelled water being equal to the reduction volume of the sample and hence the reduction of void ratio. Complete consolidation will not occur until the clay particles are everywhere in close contact, which means that the whole of the bound water at the middle of the block will have to travel a distance h as shown by the arrows in Fig. 5; the pore water near the drainage surface will be expelled almost instantaneously, but towards the middle of the block there will be a time lag consequent on the longer paths to be traversed. Simultaneously the porosity of the outer layers decreases and the time of expulsion will increase with the greater resistance to flow. Thus if the sample is subjected to a constant load and records are taken of the consolidation at time intervals from the application of the load, a graph can be constructed as Fig. 7, showing the consolidation plotted against time.

The practical utility of graphs, such as those shown in Figs. 6 and 7, is at once apparent if the laws of model similarity are admitted. By their use it is possible to tell the equilibrium density under any load and the time it takes to reach that state. Consider a portion of the curve, Fig. 6, showing a void ratio decrease from e_1 to e_2 under the increment of load dW. The reduction of the void ratio means a reduction of the volume of the clay block and as the area remains the same there must be a reduction of height. Then approximately,

$$h_2 = h_1 - \frac{e_1 - e_2}{1 + e_1} h_1$$
$$= h_1 \left(1 - \frac{e_1 - e_2}{1 + e_1}\right) \quad . \quad . \quad (5)$$

where

h_1 = half thickness of block under load W, and
h_2 = half thickness of block under load W + dW.

Thus, if the thickness of the specimen is 1½ in. at a void ratio of 0·74 and the additional loading of dW reduces the void ratio to 0·73, we can apply this by similarity to the original stratum where the thickness is 20 ft. Therefore, under an equivalent condition of loading and similar change of void ratio, the settlement of the stratum would be

$$\frac{0{\cdot}74 - 0{\cdot}73}{1 + 0{\cdot}74} \times (20 \times 12) = 1{\cdot}37 \text{ in.}$$

(To be continued.)

LITERATURE.

Mechanical Vibrations. By PROFESSOR J. P. DEN HARTOG. Second edition. London: McGraw-Hill Publishing Company, Limited. [Price 35*s.*]

CONSIDERED either as a text-book for the student or as a reference work for the practising engineer, *Mechanical Vibrations* is a notable technical work, because the author succeeds in the rather uncommon achievement of combining the logical precision of the mathematician with the hard practical wisdom of the engineer. Since the publication of the first edition in 1934, important advances have been made in the subject and most of these are discussed in the second edition. Otherwise the structure of the work is unchanged. The opening chapter deals with the kinematics of vibration, representation by vectors and complex numbers, beat phenomena, etc. An important addition is a tabulation method for performing an harmonic analysis. The next chapter, on free and forced vibrations, with and without damping, in systems having a single degree of freedom, introduces the fundamental theory underlying all vibration study.

Practical examples show that the theoretical treatment developed in this chapter explains resonance phenomena in many machines, enables the natural frequencies of a number of structures to be evaluated, and leads to an intelligent understanding of the action of most vibration-measuring instruments. The principal new material, relating to electrical methods for measuring and recording vibrations, is of considerable importance, since the intelligent use of measuring equipment in diagnosing vibration troubles is an outstanding feature of present-day vibration engineering.

Chapter 3, dealing with systems having two degrees of freedom, extends the theory previously given and enables the action of most vibration-absorbing devices to be discussed. It contains a simple but adequate treatment of friction-damper theory. Damped and undamped, forced and free vibrations of systems having many degrees of freedom are discussed in Chapter 4, which covers the vibration of strings and organ pipes; the longitudinal, lateral, and torsional vibration of uniform bars; and systems comprising a number of concentrated masses, flexibly connected. Methods for

dealing with beams of variable cross-section, whole and partial rings, and membranes and plates are included. An interesting section has been added, relating to the state of motion of a beam after the sudden application of a load.

Troubles peculiar to reciprocating engines occupy the next chapter, in which a study of the dynamics of the crank mechanism is followed by a short analysis of the inertia balance of engine aggregates. New material relates to the inertia balance of Vee engines and the effect of articulated connecting-rod systems. The greater part of this chapter is devoted to torsional vibration in engine systems. Although space limitations prevent the author from doing full justice to this subject, there is sufficient detail to enable the reader to cope with many types of directly-coupled engine transmission systems and the simpler geared installations. The notes on propeller damping should enable vibration stresses corresponding to the fundamental mode of vibration of marine installations to be computed with reasonable accuracy. Engine damping is only briefly discussed, with the help of an empirical formula based on the theory of elastic hysteresis damping. The author quite frankly points out that this formula is based on the results of experiments carried out on soft steel "in the dim past," and so disregards the more recent work of Dorey. It would be helpful if he would indicate in future editions the degree of reliability that can be placed on vibration stresses obtained by application of this empirical expression.

This chapter concludes with descriptions of several types of vibration-damping devices, including a new section dealing with the rotating-pendulum vibration absorber. This is undoubtedly a powerful means for dealing with vibration troubles; it is to be regretted, therefore, that the impression is conveyed that the best method of using the device is to tune it in resonance with the harmonic order to be reduced. The principal disadvantage of resonance tuning is the difficulty of maintaining the dimensions of the absorber within sufficiently close limits to prevent what the author calls "overtuning" or "undertuning." In most cases this disadvantage disappears if "inertia" instead of "resonance" tuning is employed. Inertia tuning merely implies that the proportions of the absorber are chosen so that, for the harmonic order to be reduced, the inertia at the point of attachment of the absorber is maintained between suitable limits which may lie almost anywhere between plus and minus infinity. Contrary to the idea underlying the use of "resonance" tuning, there are many cases where the most favourable results are obtained by tuning the absorber so that the inertia lies between zero and a small negative value. Apart from the foregoing criticism, however, the author's treatment explains fundamental principles in a remarkably clear manner, serving as an excellent introduction to the more detailed study of the rotating-pendulum absorber. The bibliography omits to cite an important paper on pendulum vibration absorbers, entitled "The Elements of Pendulum Dampers," by R. W. Zdanowich and T. S. Wilson (*Proc. I. Mech.E.*, vol. 143, page 182, 1940).

Chapter 6, on critical, or whirling, speeds of rotating machinery, discusses the influence of bearing flexibility and gyroscopic effects; and the excitation of secondary critical speeds by shafts of non-symmetrical cross-section, or by mass unbalance, or by gravity. Frame vibration and the vibration of turbine wheels and blades also come within its scope. Additional material on the balancing of solid and flexible rotors includes descriptions of the latest types of automatic balancing equipment. A noticeable omission, however, is a description of field-balancing technique, which is becoming rather important in connection with the balancing of airscrews under operating conditions. The most important addition, however, is undoubtedly the matter relating to the influence of airscrew blade flexibility on the vibration characteristics of aero-engine installations. Although a completely satisfactory theoretical treatment of such complex systems has not yet become available, the author's material is thoroughly up-to-date.

In Chapter 7 the reader enters deeper waters, and here the author draws upon his wide experience of practical vibration problems to introduce some truly fascinating branches of vibration study. General notes on self-excited vibrations, including the development of a mathematical criterion for the stability of such systems, lead to discussions of instability caused by friction, the "galloping" of electrical transmission lines, autorotation, the hunting of engine governor systems, vibration of Diesel-engine fuel-valve systems, axial oscillation of turbines caused by steam leakage, aeroplane wing flutter, and automobile "shimmy." The practical examples range from violin strings to locomotive driving wheels, with boiler rooms and draw-bridges thrown in for fuller measure. The treatment of hunting in direct-acting governor systems is excellent, and, in future editions, might well be extended to cover indirect (or relay) governors.

The final chapter deals with systems having variable or non-linear characteristics, commencing with several cases of systems with variable elasticity and then proceeding to the more general case of a system in which mass, spring stiffness, or damping vary with displacement. The author rightly points out that, in mechanical systems, the mass is usually constant and the non-linearity is generally confined to the controlling springs or the damping, while in electrical systems there are important cases where the non-linearity is found in the mass. Approximate theoretical methods are given for dealing with free and forced vibrations of systems with non-linear elasticity or non-linear damping. The chapter concludes with a discussion of relaxation oscillations where the motion is usually distinctly non-harmonic. The author mentions, however, that although this type of vibration has been found to occur very often in radio engineering, it has so far been of little importance in mechanical engineering. Professor Den Hartog handles this most difficult branch of his subject in a masterly fashion. The only regret is that he does not include references to the influence of gear-tooth backlash on torsional vibration in geared systems, and the use of non-linear spring couplings for detuning purposes.

The work concludes with two appendices, one giving a short treatment of the elementary properties of the gyroscope and the other a useful collection of formulæ; a short but up-to-date bibliography; and answers to the well-chosen problems at the end of each chapter. This is a book which can be wholeheartedly recommended, even to those who already possess the first edition.

Air Navigation. By F. G. BROWN, B.A., B.Sc. London: Chapman and Hall, Limited. [Price 32s. net.]

AIR navigation to-day is in a transitional stage, in which the airman hardly cares to be reminded of his debt to sea navigation by marine analogies, although his work is still far from being standardised. In these circumstances, every new book on air navigation is open equally to unusual criticism and cordial welcome. The present work, first published in Australia a year ago, is one for advanced students of sea, as much as of air, navigation; indeed, it could well have borne the dual title. Astronomical navigation is thoroughly dealt with. It is the author's contention that "Astro" is no more difficult of comprehension than any other aspect of the navigator's art. That may be so, but the air cadet does not need it first; and the subjects that he does need—maps, map-projections, map-reading, and drift and wind finding—are less thoroughly covered, while instruments and their use, meteorology, signals and legislation have been left entirely to other specialist writers. It may be true that a simple knowledge of mathematics will enable a beginner to grasp all the arguments offered in explanation of navigational problems. Mr. Brown's ample treatment of compass deviation, for example, seems to call for a background of mathematical practice, as distinct from scholarship, which only an experienced mathematician would describe as simple. A modern navigator can employ Hughes', or other, Tables to compensate for ignorance of the processes of spherical trigonometry. Mr. Brown argues, fairly enough, that anyone clever enough to do this in the air should easily master the mathematical operations that they circumvent; so he sets out, regardless of convention, to teach his student how to achieve the satisfaction of being able to answer the question "Where am I?" in the early chapters of the book.

Position finding by trigonometrical solution of the astronomical triangle, using only one all-haversine formula, as well as by means of Hughes' Tables, which are fully explained, is thoroughly and effectively covered; and, before position lines and the reduction of sextant observations to obtain true altitude are discussed, a helpful chapter on applied mathematics is included. Later chapters deal with the sailings, direction, conversion, magnetic deviation, deviation caused by acceleration, time, and wind problems. An excellent chapter of examples deals with points not considered elsewhere in the book and with a number of questions from papers set in the examinations for the First-Class Civil Licence. These problems are ideally answered, and the answers are enlivened by some pithy comment on the foibles of examiners.

Mr. Brown's style of writing is a sure indication that he loves his craft and knows how to teach it. every facet of each problem being handled with the facility of a master; and if there are times when his reiterated elucidation of some knotty point has led to the tedium and uncertainty which over-simplification can induce, there are more occasions when his original exposition of some elusive concept has proved outstandingly enlightening. It is neither necessary nor correct to imagine the earth at rest in order to understand how time is measured, for instance; but it would be hard to find a clearer explanation of the subtleties of Mercator sailing than the one so admirably illustrated in this volume. The numerous diagrams throughout the book are consistently good, and they are to be found where they are best suited for reference. Only two insignificant misprints were noticed in nearly 400 pages, which include tables of recalculated five-figure haversines, as well as logarithms and other useful tables; but a definition of true horizon, on page 24, as "a plane everywhere 90 deg. from my Zenith" is obviously inadequate. There could be many such planes, none of which would comply with the correct definition of true horizon given on page 68. This book deserves the attention of all navigators, and is certain of a good reception.

Practical Cost Accounts. By ANDREW MILLER. Second edition. Potters Bar: Gee and Company (Publishers), Limited. [Price 10s. net.]

DURING recent years there has been no lack of manuals on costing as applied to engineering manufactures, but many of the works of this type suffer from one or other of two defects; either they pursue the subject with such a minuteness of detail that, in attempting to adapt their teaching to a particular purpose, difficulty is encountered in determining what details to discard, or they approach it solely from the theoretical standpoint and imbue the reader's mind with the impression that the author is insufficiently familiar with actual works practice. From these shortcomings Mr. Andrew Miller's writings have always been refreshingly free, as becomes the considered opinions of a director and secretary of an old-established engineering business, and of the present book it may be said at once that it thoroughly lives up to the promise of its title.

The principal additional matter incorporated in the second edition consists of two new chapters dealing, respectively, with "Standard Costs" and "Budgetary Control." As with the earlier chapters, there is appended to each of these a series of typical examination questions; selected, in these instances, from papers recently set in the examinations of the Institute of Chartered Accountants and the Institute of Cost and Works Accountants. Some of the questions accompanying the previous chapters are taken from the same sources, though others appear to have been composed on the basis of the subject matter to which they relate; all, however, are of a definitely practical nature and form, in effect, compact summaries of the main points covered in the chapters themselves. A collection of graphs and typical costing forms, attached as a folder in the back of the book, indicates the application of the methods described to particular circumstances. There is a good index, and a brief foreword on the importance of accurate and efficient costing is contributed by Lord Weir.

CEMENTS FOR GLASS INSERTS IN ELECTRICAL APPARATUS.

THE fixing of glass or porcelain insulators to metal parts by means of cement in the construction of switchgear and other apparatus, has been a practice employed in electrical manufacture since the early days. At one time a mixture of sulphur and ground glass was extensively used for porcelain, the well-known litharge and glycerine cement being employed for the finer classes of work. This latter material is still in extensive use, but much work is also done with cements of the calcium-sulphate type. As certain new products of this latter class have been introduced, an investigation has been carried out by the British Electrical and Allied Industries Research Association in order to elicit information bearing on the performance of these materials in practice. New experience has been accumulated by manufacturers, owing to the fact that certain cements previously in use are of foreign origin and are not now available. The results of the investigation are embodied in Technical Report Ref. G./T. 131, prepared by Mr. A. P. Paton, and bearing the title "Recent Experience with Calcium Sulphate and Other Types of Cement for Glass Inserts in Flameproof Enclosures." Calcium-sulphate and iron cements were dealt with in Report Ref. G./T. 114, issued in September, 1939, but since that time, as stated above, new cements have become available.

The report, which is based on replies to a questionnaire directed to firms interested, includes information, gathered in the same way by Mr. J. A. B. Horsley, the Electrical Inspector for Mines, concerning flameproof electric-light fittings. The inquiry was initiated to obtain data bearing on the performance of a newly-developed product known as Kaffir Plaster EN., in order to ascertain if it could be recommended as a substitute for Axe brand cement. This latter product, being of German manufacture, is now unobtainable, and various firms that have used it in the past have been considering employing Cafferata's C. Fine Keene's cement or litharge and glycerine cement as an alternative. The report suggests that experimental investigations may possibly be carried out on the matter, but has been published at this stage in order that users may have the benefit of the information already collected.

In the summary of the replies received to the questionnaire, which is given in the report, it is emphasised that only information bearing on the use of cement for glass fitments in flameproof electrical gear, or lighting fittings, has been embodied. Particulars concerning the use of cements for other purposes have not been included. Five users stated that they preferred litharge and glycerine because it could be used in the presence of oil, was cleaner and more controllable. One of these users had tried *Ciment Fondu* as an alternative, but discarded it owing to the length of time necessary for setting and undue expansion or contraction in normal atmospheric conditions. Another had discarded Axe brand cement, presumably because it could not be obtained, and a third having tried iron cement as an alternative found that it was porous and set too quickly. In contrast to these five users, another who had adopted C. Fine Keene's as being "easy and sure" had found litharge and glycerine variable and too exacting for workshop labour. A seventh firm, however, thought C. Fine Keene's slow in hardening and had adopted EN Kaffir Plaster.

A table is given in the report summarising the information collected on the quantities of cement mixed at a time and used for each article, and the time necessary before the articles could be released from the jigs. The amount mixed, which will obviously be related to the scale of operations and the number of workpeople engaged in making the joints, in one case was as high as 16 lb., but in no other case was as much as half that amount mixed, and for many users the figure was from ½ lb. to 1 lb. The amount of cement per article varied from ½ oz. to 8 oz. Of more general interest is the information bearing on the time the articles are left in the jigs. This varied from a maximum of 48 hours to a minimum of ¼ hour. This latter figure was exceptional, and referred to meter glasses and windows fixed with Hawkins iron cement. A minimum period of ½ hour was, however, given for flameproof lighting fittings and cover glasses of housings fixed with C. Fine Keene's. The figures varied a good deal and were not closely related to the type of cement. Litharge and glycerine was shown by different users to have minimum times of 1½, 4 and 4 to 24 hours. The C. Fine Keene's minimum ranged from 6 to ¼ — 12. The figures for commercial Keene's were more consistent, with a minimum time of 1½ hours. Where a large range was quoted the actual time allowed would be determined to some extent no doubt by ambient temperature conditions. It was hoped to collect information bearing on the effect on time of setting of the addition of gum or size to calcium-sulphate cements, but no user supplied data on this question. In one case it was stated that 2½ lb. of gum arabic to a gallon of water was used in making up C. Fine Keene's cement. No difference in strength was found and the cement adhered more firmly to glass and metal.

In report Ref. G/T 114, it was stated that C. Fine Keene's cement, under certain conditions, might give rise to electrolytic action if used with Bakelite. This cement is essentially an anhydrous calcium sulphate which is slightly acid, due to the addition of a small percentage of alum. The presence of this potassium salt is considered undesirable when the cement is in contact with insulation of the synthetic resin impregnated type, and alternative cements were under investigation at the time the earlier report was issued. These alternatives, which have now been developed, are termed Kaffir Plasters. They consist of calcium-sulphate hemi-hydrate and their manufacturers, Messrs. Cafferata, consider them superior to C. Fine Keene's cement in all respects. It is stated, for example, that in work involving very small quantities there is a risk of C. Fine Keene's cement drying out without adequate hydration, but the plasters hydrate almost fully within 2 hours so that dry-out is almost impossible. The material produced by C. Fine Keene's, Kaffir Plaster EN, and Kaffir Plaster EA when set, is gypsum, but the plasters, especially the EN type, produce a denser form.

The report states that it is a little unfortunate that the word "plaster" conveys to the general public the idea of a product which is inferior in strength and performance to a "cement." Actually, it is technically accepted in the gypsum trade that a cement is a high-temperature dead-burnt product and that, without exception, all hemi-hydrates are designated plasters. The specially-prepared hemi-hydrates known as Kaffir Plasters, while chemically similar to plaster of Paris are different in their mechanical and physical properties and give strength figures many times higher than those of plaster of Paris. Kaffir Plasters meet the need for a rapidly-hardening material, which is more suitable than Keene's cement for use in conjunction with synthetic-resin impregnated insulation, as they contain no sodium or potassium salts. They harden rapidly and jigs may be freed in from 2 hours to 3 hours, instead of 6 hours which is the time recommended for C. Fine Keene's. Of the two new plasters, EN gives the greater strength and, being neutral, is entirely non-corrosive. It has a higher setting expansion than EA, which is usually an advantage in providing a stronger lock. EA plaster is alkaline, due to a small percentage of calcium hydroxide. Its setting expansion is less than that of EN, so that it is recommended for use in joining delicate parts for which setting expansion has to be kept to the lowest limits. Both plasters may be manipulated for about 30 minutes after mixing, during which they remain practically inert. They may be readily vibrated or jarred into any space they are required to fill. The EN type has more latitude than Keene's, and may be used at pourable consistencies without loss of strength.

The report contains information furnished by two firms who have investigated the performance of Kaffir plasters in practice. One states that the purpose, for which they have previously used Axe brand cement, is the securing of metal fittings to porcelain insulators. Litharge and glycerine are not employed owing to the critical importance of a correct mixture being used, which may lead to inconsistent results under works conditions. They have tried C. Fine Keene's and Kaffir EN, and consider the latter to be preferable. It is a quite satisfactory substitute for Axe brand cement, and is much less affected by exposure to outdoor conditions, or to oil, than is C. Fine Keene's.

The other firm had used C. Fine Keene's with satisfactory results for many years. Before contemplating changing over to Kaffir Plasters, some comparative experiments were made and these appeared to indicate that the setting time of the Kaffir Plasters was longer, their expansion greater, and their strength not so high as C. Fine Keene's. The firm accordingly got into touch with the manufacturers and learnt that Kaffir Plasters give their best results when allowed to set in the presence of mild heat and not in a damp atmosphere, and that they could be manufactured to have an initial setting time of the order of 10 minutes. The manufacturers also drew attention to the fact that the setting of these plasters begins slowly and suddenly speeds up. Although the tensile strength of Kaffir EN might be less than that of C. Fine Keene's in the experiments carried out at the end of the setting time, of the order of one hour, it would have been found to be greater at the end of two hours. Further comparative tests on C. Fine Keene's and Kaffir EN were then made, and it was found that although the initial set of Kaffir EN took longer, in two hours it had reached a tensile strength fully equal to that acquired by the cement in seven days. It was considered that this feature of the plaster was an advantage, as more time was available for mixing and assembling, and yet the work could be removed from the jigs with greater safety and after a shorter delay. Half an hour was saved on each insulator. The expansion shown on the Le Chatelier apparatus was 2 mm. for the plaster, and 1 mm. for Keene's, against a permissible figure of 10 mm. for Portland cement. It was finally concluded that all tests showed Kaffir EN to be an improvement on C. Fine Keene's.

BEARING ALLOY FOR USE IN SEA WATER.

THE selection of a satisfactory material for the tail-shaft bearings of liners and other large ocean-going vessels presents a number of problems; the bearings are immersed in a rapidly moving stream of aerated sea water, and as they are in contact with a large mass of steel similarly exposed, the tendency to corrosion is accelerated by electrolytic effects. In addition, lubrication during a voyage presents difficulties. Lignum vitæ has been widely employed, in spite of such complications as the necessity for using bronze shells for the strips of the wood and bronze bushes on the steel propeller shafts. From the mechanical point of view, white-metal alloys are more easily fitted, and although subject to electrolytic corrosion, they possess valuable anti-friction qualities. The whole question of tin bearing metals for use in sea water is at present under investigation in the laboratories of the Tin Research Institute, and an account of the work so far carried out is given in a brief report by the research manager, Dr. E. S. Hedges, contained in a recent publication of the Institute. Dr. Hedges states that a white-metal alloy which has been widely employed for ships' tail-shaft bearings contains tin, zinc and copper, and it has been taken as a basis of comparison throughout the Institute's investigations. The main object of the research was to find an alloy which, under working conditions, had the same electro-potential as mild steel and, in addition, possessed anti-friction qualities at least as good as those of the representative alloy, which is referred to as "Alloy X."

Initial tests were made on the corrosion (alone and in contact with mild steel) of a number of tin-rich alloys in a 3 per cent. sodium-chloride solution, and on the difference in electro-potential between these alloys and steel. The more suitable alloys were then tested for anti-friction properties, both when running in oil and in sea water, and, finally, the behaviour of the various alloys as bearings was compared in an apparatus in which a shaft rotated in the bearings in the presence of highly-aerated sea water under simulated service conditions. In the electrochemical tests one alloy was found to be equi-potential with mild steel in aerated sea water. This alloy also proved to have superior anti-friction properties, especially when running in sea water without oil lubrication. In Table I,

TABLE I.—*Electrochemical Behaviour and Corrosion in 3 per cent. Sodium-Chloride Solution.*

Alloy.	E.m.f. Against Mild Steel.	Loss in Weight.			
		5 days at Room Temperature.	5 days at 25 deg. C. with Aeration.	21 days at 25 deg. C.	21 days at 25 deg. C. in Contact with Steel.
		Mg.	Mg.	Mg.	Mg.
Alloy X ..	−0·34	14·3	36·6	187·0	857·3
High-tin alloy.	+0·25	Not measured.	3·2	89·0	12·1
New alloy	+0·01	13·8*	3·5	13·4	42·9

* Gain in weight.

the behaviour of the new alloy is compared with that of Alloy X and with that of a high-tin bearing metal having the following percentage composition: tin, 89·5; antimony, 7; and copper, 3·5. The coefficients of friction of the three alloys, against steel, in oil, at loads ranging from 1,280 lb. to 10,240 lb. per square inch, with a rubbing speed of 1,250 ft. per minute at a temperature of 40 deg. C., were also determined. At all the loads the new alloy was apparently superior to the other two. The behaviour of the new alloy when tested as a bearing in highly-aerated sea water under simulated service conditions in the Institute's special apparatus showed it to be as good as the high-tin alloy and quite definitely superior to Alloy X. In these tests the rubbing speed was 750 ft. per minute and the bearing pressure 70 lb. per square inch.

Dr. Hedges states, in conclusion, that the new alloy is easily made at 350 deg. C., and is cast at about 300 deg. C. It has a high degree of adhesion to steel, the bond strength being 11·4 tons per square inch in tension and 5·1 tons per square inch in shear. The Brinell hardness number is 35·7, and the tensile strength 7·4 tons per square inch. We note that the Institute hopes to arrange a practical full-scale trial of the alloy in a ship's tail-shaft bearings.

AMERICAN SOCIETY FOR TESTING MATERIALS.

WE conclude below our brief summaries of the more important reports and technical papers presented during the course of the 44th annual meeting of the American Society for Testing Materials, held in Chicago from June 23 to 27. Previous abstracts will be found on pages 186 and 225, *ante*.

WATER FOR INDUSTRIAL USES.

One phase of the work of the Society which is relatively new—at all events, in comparison with the work under way in other fields—relates to water for industrial uses. During the past two years, the Society's Committee D-19 has done a great deal of work on methods of testing. Interest at the meeting, however, was mainly concentrated on a "Symposium on Problems and Practices in Determining Steam Purity by Conductivity Methods." In the first paper of the symposium, entitled "The Sampling of Steam and Boiler Water," the authors, Messrs. A. R. Belyea and A. H. Moody, pointed out that the extension of steam temperature and pressures to higher values in modern steam boiler and turbine design imposed stricter requirements on the sampling of the water employed. Of particular importance were accuracy in sampling and the avoidance of the possible contamination of the sample by the sampling equipment. It was vital that sampling tubes, cooling coils, and sample containers should preserve the integrity of the sample and, for this reason, the materials from which these utensils were made must be carefully chosen. The limited data available, to which could be added general information on the properties of ferrous and non-ferrous materials, indicated that stainless steel, copper and copper alloys, and nickel and nickel alloys had definite fields of usefulness for sampling purposes. Precise knowledge of the chemical constituents present in the sample taken and in the cooling water was essential to the making of a proper choice of material. This was a point which might be discussed with advantage with the producer of the metal.

"Experimental Methods of Determining Conductivity Correction Factors for Dissolved Gases in Steam Condensate" was the title of the second paper, which was by Messrs. S. F. Whirl and W. A. Lower. This paper presented a critical survey of the various methods which had been advocated for correcting conductivity determinations in steam-condensate samples for the presence of interfering dissolved gases, principally ammonia and carbon dioxide. In general, the basis of these methods had been either the application of correction factors for the amounts of ammonia and carbon dioxide present, as determined by analysis, or an attempt at gas removal prior to the conductivity measurement. On account of inaccuracies, or because of the complicated analytical procedure involved, however, none of these methods was entirely satisfactory. To avoid the errors inherent in these methods, a fundamentally different procedure had been developed in the authors' laboratory. The gases were distilled from the sample (which was made successively alkaline and acid) and were collected in relatively pure water. The conductivity of the latter was determined, and the subtraction of a blank determination value then gave directly a single figure for the combined effects of all the gases.

TIMBER.

Committee D-7 on Timber recommended the approval of a new definition of water-gas tar. This definition stated that water-gas tar was tar produced in the manufacture of carburetted water-gas by the decomposition of petroleum oil by heat in the presence of blue gas. An interesting paper in this section was presented by Mr. W. A. Oliver, and was entitled "Tests of Glued Laminated Wood Beams Impregnated with Creosote." Mr. Oliver said that the size of the specimens employed was that recommended by the Society for small clear specimens to be tested in cross bending, namely, 2 in. by 2 in. in cross section and 28 in. in span, the load being applied at mid-span. Plain solid beams and glued laminated untreated beams were tested side by side with the treated specimens and the tests were conducted at intervals of approximately three months, extending over a period of one year. The results obtained indicated that, for all practical purposes, the glued and treated laminated beams, when properly seasoned, had the same strength as either the plain beams or the glued, untreated, laminated beams. A full-size glued laminated wood beam could be made up of a number of smaller pieces of timber in such a manner as to eliminate many of the natural defects which might be present in a solid beam of the same size. Consequently, it seemed logical to expect that the results obtained from full-size tests would be even more favourable to the glue treated beams.

CONCRETE.

Several of the papers presented at the session dealt with questions relating to concrete and concrete aggregates. One of these was entitled "The Effect of Capping Methods and End Conditions, before Capping, upon the Compressive Strength of Concrete Cylinders." The author, Mr. G. E. Troxell, stated that compression tests had been carried out on 768 cylinders of carefully-controlled concrete and that the capping materials employed comprised (*a*) Hydrostone, a high-strength gypsum product; (*b*) Castite, a sulphur-silica mixture; (*c*) oiled steel shot; (*d*) dry steel shot; and (*e*) plaster of paris tested after ageing for 30 minutes and for one hour. Four definite "end conditions" were selected for investigation, namely (1) plane ends normal to the axis of the cylinder; (2) plane ends not normal to the axis; (3) convex ends; and (4) concave ends. The results showed that, of the five capping methods employed, the last three mentioned (*c*, *d* and *e*) gave lower test figures than the first two (*a* and *b*), the differences being specially large for other than plane ends normal to the axis of the cylinders. Moreover, considering overall costs of labour and materials, Castite caps were cheaper than those made of any of the other materials tested.

Some of the papers in this section were concerned with proposed revisions of tests for concrete and concrete aggregates. In dealing with "Size, Shape, Surface Texture, and Grading of Aggregates," Professor H. J. Gilkey stated that it must be constantly borne in mind that tests were significant only if the results were properly representative of the material to be used. In the matter of aggregates, precautions relating to the selection of samples were of the utmost importance. Results which fairly represented the average for a large bin or stock pile might be worthless if, within the mass, there was much segregation of sizes, since local variations caused fluctuations from batch to batch of the finished concrete. Mr. M. A. Swayze, in pointing out the significance of "Density and Unit Weight of Concrete," stated that the control of air content in concrete by specification limits would seem ill-advised at the present time. The results obtained were so dependent on cement content, concrete consistency, and even method of mixing that a specification of this kind would have to cover an extremely wide range of values. The matter of "Permeability and Absorption of Concrete" was dealt with by Professor M. O. Withey, who stated that the test for permeability to water vapour furnished information concerning the amount of water which might pass through an uncracked wall of concrete, of a given mix, when subjected to differences in vapour pressure on the opposite faces. The capillarity-evaporation test enabled estimates to be made of the amount of water which was likely to be evaporated from the free surface of a concrete wall or slab when the opposite face was in contact with water or was under a head of water too low to cause leakage.

BENDING AND STRAIGHTENING MACHINE.

MESSRS. JOSHUA BIGWOOD AND SON, LIMITED, WOLVERHAMPTON.

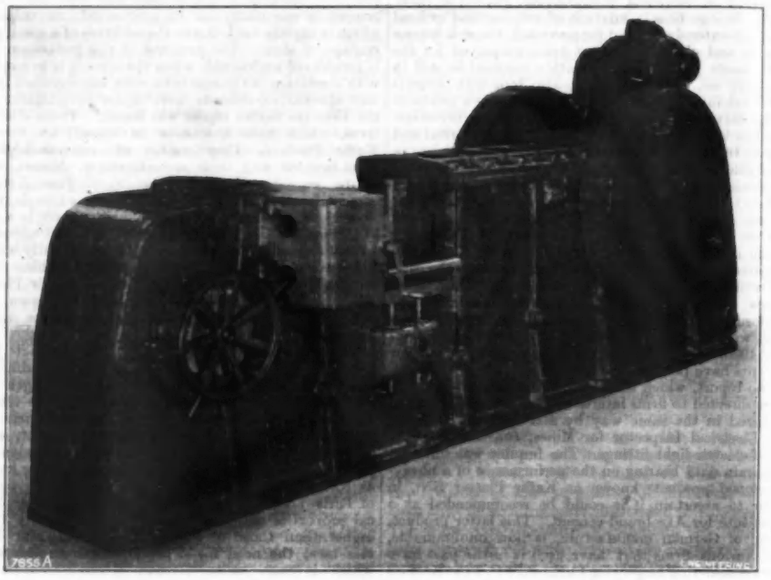


FIG. 1.

HORIZONTAL BENDING AND STRAIGHTENING MACHINE.

THE horizontal bending and straightening machine illustrated in Figs. 1 to 3, on this and the opposite pages, is an example of machines recently constructed by Messrs. Joshua Bigwood and Son, Limited, Wolverhampton, for straightening aluminium and light-alloy slabs, but with a driving motor of 20 h.p., the particular machine illustrated will straighten solid steel bars up to 10 in. square in cross section without stalling. Incidentally, this type of machine is widely used for the bending and straightening of steel joists, rails and other rolled sections of which relatively small quantities are required, the handling of large quantities being carried out by Messrs. Bigwood in their roller straightening machines. The external appearance of the machine is seen in Fig. 1. It has an overall length of 18 ft. 5¼ in., a height of 8 ft. 1½ in. from the floor to the top of the motor cable box and a maximum width, over the traversing gear of the pressure head, of about 5 ft. 10¼ in. The main frame consists of a pair of steel side castings with a machined joint down the centre, these halves being bolted firmly together and bending stresses being taken off the bolts by tongues and grooves. Towards the centre of the machine the side castings are, however, connected by a ribbed steel cover spanning the ram slide, while the pressure head, to the left of Fig. 1, acts also as a further cross-connection. The whole frame is, therefore, of box construction and houses all the working parts with the exception of the driving gears.

The general construction of the machine will be clear from the drawings reproduced in Figs. 2 and 3. The pressure head is indicated at *a*, and the ram at *b* and *c*, the ram being in two parts which are adjustable relatively to each other. The ram is reciprocated, with a stroke of 3 in., by the eccentric *d* which is coupled to the front end of the ram *c* by the sheave *e*. The eccentric is integral with its shaft, the whole being machined from a single forging of high-tensile steel, which runs in wide bronze bearings, as shown in Fig. 3. The shaft is driven by a large spur wheel on each side meshing with pinions on the second-motion shaft which, in turn, is driven by a central spur wheel meshing with a pinion on the first-motion shaft. This shaft is coupled to the flywheel and driving pulley by a slipping clutch, as seen in Fig. 3, the clutch being adjustable so that slipping takes place within the pre-determined safety limits. Transmission from the motor is by means of multiple Vee-belts. The motor is mounted on a hinged base, as shown in Fig. 2, with screw adjustment to provide the necessary belt tensioning. It will be seen from Fig. 1, that all the gears outside the frame are provided with effective guards. The motor, as already stated, is of 20 h.p. It runs at 710 r.p.m. on 520-volt, three-phase,

CRANK-OPERATED BENDING AND STRAIGHTENING MACHINE.

MESSRS. JOSHUA BIGWOOD AND SON, LIMITED, WOLVERHAMPTON.

Fig. 2.

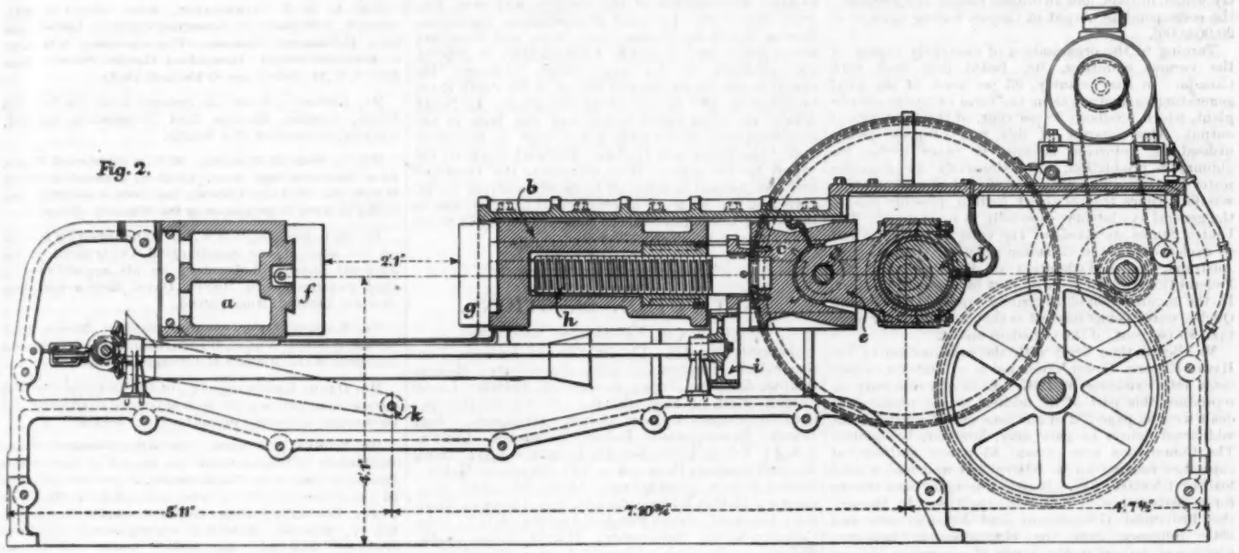
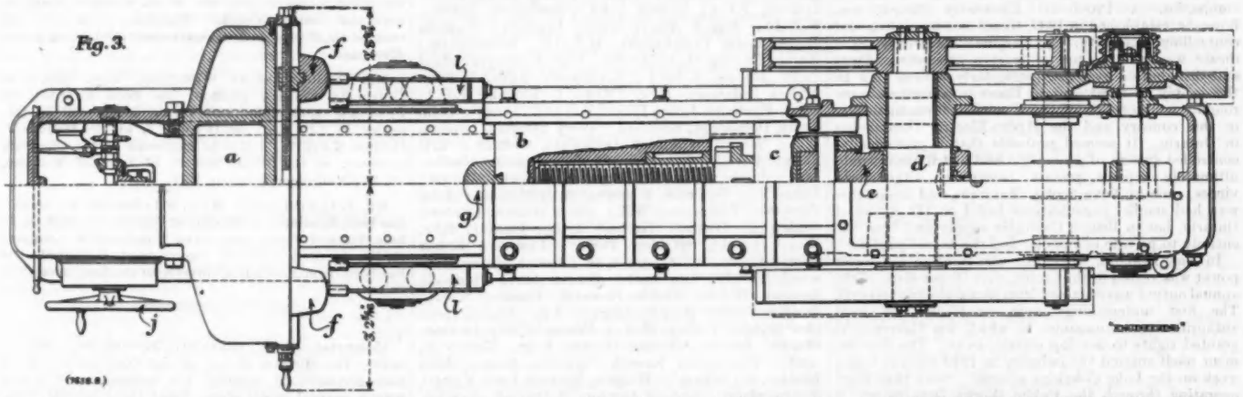


Fig. 3.



50-cycle current and is manufactured by Messrs. The General Electric Company, Limited, Kingsway, London, W.C.2. The speed reduction through the gears, which are all of steel with machine-cut teeth, is such as to give 25 working strokes per minute of the ram.

The pressure head *a* has a dovetail slide on the face along which are traversed, by means of a right and left-handed screw with bronze nuts, the pallets *ff*. The screw is operated by a crank handle, and the pallets can be set with their centres at any distance apart between 9 in. and 4 ft. 2 in. The ram *b* carries a single central pallet *g*. The distance between the pallet faces is 25 in., when the ram is in the position and condition shown in Fig. 2. Pallet *g* is dovetailed into the ram, which is kept horizontal by means of the slides seen in Fig. 1. The two parts of the ram are connected by the screw *h*. This is secured to the part of the ram coupled to the eccentric sheave by means of a collar so that it is free to rotate and, by so doing, either to increase or decrease the distance between the face of the pallet *g*, and the centre of the eccentric to suit the dimensions of the material under treatment. The rotation of the screw is effected by a spur ring keyed to it and meshing with a spur wheel *i*, attached to a shaft running along the centre of the frame. This spur wheel is 3 in. wider than the spur ring, so that the meshing of the two is maintained at whatever portion of the stroke the part *c* of the ram may be. To the other end of the wheel shaft is keyed a bevel wheel meshing with a bevel pinion which can be locked by a dog-clutch to a cross-shaft carrying the large handwheel *j*, seen on the left in Fig. 3, and also in Fig. 1. Rotation of this handwheel therefore separates or draws together, as may be required, the two parts *b* and *c* of the ram, the relative position of the two being indicated by the large graduated dial seen behind the handwheel in Fig. 1.

Referring to the left of Fig. 3 it will be seen that the handwheel shaft carries a chain sprocket wheel and that this is also provided with a dog-clutch. A pull and push rod actuates the dog to engage either the bevel wheel or the sprocket wheel. In the first case rotation of the handwheel lengthens or shortens the ram as already described, while in the second case rotation of the sprocket drives, by means of a roller chain, a cross-shaft *k*, Fig. 2, passing through the frame of the machine at a point about midway between the pallets when fully separated. One end of the cross-shaft can be seen in Fig. 1 in the centre of a projecting box through which pass two vertical screws. There is a similar arrangement on the other side of the frame. The cross-shaft is furnished with a worm at each end meshing with a pair of worm wheels which are, in effect, nuts on the vertical screws. These screws carry U-frames supporting rollers *ll*, Fig. 3, on which rollers the section or bar under treatment rests, the height to the rollers being adjusted by the handwheel so that the centre of the work coincides as nearly as possible with the centre line of the ram and eccentric shaft. The rollers, of course, enable the work to be readily traversed as required. The space between the frames in way of the rollers is covered in by a light plate as shown in Fig. 2. The machine is hand lubricated, the two eccentric sheave bearings being reached by means of flexible pipes.

METALLURGICAL MEETINGS IN BIRMINGHAM.—The Birmingham local section of the Institute of Metals hopes to arrange, in conjunction with the Midland Metallurgical Societies, a programme of seven monthly meetings for the session 1941-42. A tentative programme will be forwarded to each member of the section when arrangements are completed. The honorary local secretary is Mr. J. W. Jones, M.Sc., Department of Metallurgy, The University, Edgbaston, Birmingham, 15.

ELECTRICITY SUPPLY IN THE BRITISH EMPIRE.

IN his address to the London Students' Section of the Institution of Electrical Engineers, on August 27, Mr. J. R. Beard, the President of the Institution, gave an interesting account of the various ways in which the organisation of public electricity supply has been carried out in the different countries of the Empire. He began by pointing out that the ultimate possibilities of electrical development in the vast areas concerned was almost impossible to visualise. Many of the countries were but sparsely populated and it was to this country, as the chief manufacturing centre of the Empire, that they would look for electrical equipment for many years to come. It was probable that the majority of his hearers would ultimately be concerned with Empire electrical development, either by taking some part in manufacture at home, or proceeding to some Dominion or Colony for the erection or operation of plant. The close connection of the Institution with this great sphere of electrical enterprise was illustrated by the fact that already one-fifth of the total membership was made up of overseas members; these were mainly domiciled in the Dominions.

The fields of major importance were naturally furnished by Canada, Australia, New Zealand, South Africa, India and the Far East, but many of the smaller countries offered considerable scope for future development. As an example, there were enormous sources of potential water power in British Guiana, as well as in the West Indies, West and East Africa, and Palestine, the relatively small installations at present existing representing only the beginnings of power supply over large areas. The electrical manufacturing production of Great Britain for home use was valued at 109,000,000*l*. per annum; for export to the Empire 18,000,000*l*.; and to foreign countries 7,000,000*l*. In 1938, Great Britain supplied 70 per cent. of the

electrical imports of Australia, 16 per cent. of those of Canada and 51 per cent. of those of India. The figures for Eire, New Zealand and South Africa were, respectively, 66 per cent., 61 per cent. and 60 per cent. In Australia there was an electrical manufacturing industry which, in 1938, had an output valued at 5,200,000*l.*, the corresponding output in Canada having a value of 20,000,000*l.*

Turning to the organisation of electricity supply in the various countries, Mr. Beard first dealt with Canada. In that country, 93 per cent. of the total generating capacity was in the form of hydro-electric plant, which produced 98 per cent. of the total annual output. One quarter of this was off-peak power utilised for industrial heating, in paper works, for aluminium production, and extensively for domestic water heating. The general standard of consumption was four times that of Great Britain, possibly due to the general availability, especially in rural areas. The United States standards of 110 volts to 115 volts and 60 cycles, dominated Canadian practice. Canada, like Australia, was a Federation of Provinces and the Federal Government took no part in electrical matters. In the organisation of electricity supply, Ontario and Quebec were of chief interest as they accounted for more than 80 per cent. of the Canadian output.

Mr. Beard then dealt with the organisation of the Hydro-Electric Power Commission of Ontario, which came into existence in 1907. It is not necessary to reproduce this part of his address as the matter was dealt with on page 232 of our issue of last week. Some additional figures he gave may, however, be quoted. The Commission now owned 45 power stations, of capacities ranging up to 400,000 kW and had a total load of 1,500,000 kW. It acted as agent and trustee for a partnership of 850 municipalities. In Quebec, the Provincial Government had hitherto exercised little influence over the electric-supply industry, which was mainly in the hands of a number of large companies. A Provincial Electricity Board was, however, established in 1937, to act as a regulating and controlling authority. A National Electricity Syndicate was also set up to develop generating plants and distribution systems, particularly with a view to the supply of rural areas. These organisations were roughly counterparts of the Electricity Commissioners in this country and the Hydro-Electric Commission in Ontario. It seemed probable that a provincially-controlled system of generation and distribution would ultimately replace private enterprise. Other provinces, such as Nova Scotia, Manitoba and Saskatchewan had smaller organisations based on the model of Ontario, but in British Columbia supply had been left entirely to private companies and the municipalities.

In New Zealand, where the sole right to use water power was vested in the Crown, over 90 per cent. of the annual output was obtained from hydro-electric stations. The first undertakings were established by local authorities and companies to which the Government granted rights to develop certain areas. The Government itself entered the industry in 1910 when it began work on the Lake Coleridge scheme. Since that time, operating through the Public Works Department, it had built or purchased plant and transmission lines forming complete interconnected systems in each Island. The installed capacity in the North Island was 194,000 kW, and a further 174,000 kW was under construction. In the South Island there were 73,500 kW installed and 77,000 kW under construction. In 1939, Government stations generated 90 per cent. of the 1,400 million units produced. The standard distribution voltage was 400-230. Although the policy of the Government had been to generate bulk power, retail distribution had been left to local authorities or Electric Power Boards responsible for sparsely populated areas. There were 31 such boards. Conditions in New Zealand were unusual in that generating and bulk supply were in the hands of an ordinary Government department.

In Australasia, various arrangements were in operation. On the mainland of Australia, practically all development was confined to the neighbourhood of the large cities, Sydney, Melbourne, Adelaide, Brisbane and Perth. In Brisbane, the Government was encouraging the amalgamation of various small private concerns into a private monopoly, ultimately to be taken over by the Government. Sydney had several large stations for municipal and urban supply, the 75,000-kW installation at Balmain being of considerable technical interest as it operated at 1,200 lb. per square inch and 900 deg. F. The New South Wales Railways supplied its 311 miles of electrified track from its own generating station in Sydney. Melbourne had 439 track miles of suburban electrified line. In Victoria, a State Electricity Commission had been formed to undertake generation and bulk and retail supply. It had 10,000 miles of high-tension line.

In India, as in Australia, while certain districts were extensively electrified, others, particularly rural areas, were practically undeveloped. About half the total power was generated in hydro-electric stations. These were mainly situated in the North West Frontier District, the Punjab, the Tata group near Bombay, Madras and Mysore. Steam generation predominated in the United Provinces, Calcutta and Hyderabad. There was a certain amount of railway electrification, but the average consumption of the country was very low, being only 5 units per head of population. In Ceylon, Burma, the Malay States, Hong Kong and Shanghai, steam power predominated. Electrification, in general, was confined to the large towns, although the supply to the tin-mining area served by the Perak River undertaking was an important exception. In South Africa, the main development had also been in the neighbourhood of the large towns, such as Johannesburg, Cape Town, and Durban. In Natal, however, the supply for the railway from Durban to the Transvaal had been tapped at intervals to supply outlying towns. Owing to the influence of continental practice, due to the strong Dutch interest, the standard supply in South Africa was given at 380-220 volts.

INSTITUTION ELECTIONS.

INSTITUTION OF MECHANICAL ENGINEERS.

Associate Member.—Robert Edward Addison, London, S.W.1; Stephen Eric Alley, Shrewsbury; Herbert Ashton, Arequipa, Peru; Robert Bell, Belfast; Lionel Charles Best, B.Eng. (Sheff.), Walton-on-Thames; Captain Edgar Andrew Bolton, Stockport; Bert Bonell, Birmingham; Robert Broadbent, London, S.W.3; Edwin Leslie Brooks, Loughborough; Lieut. Denys Thompson Brown, R.A.O.C., Stanmore, Middx.; Robert Brown, Birmingham; Albert Buchanan, Manchester; Robert William Burkitt, B.A. (Cantab.), Reading; Derek St. Aubyn Butcher, London, W.C.2; Colin Cameron-Kirby, Manchester; Harold James Castle, Bulawayo, Rhodesia; Harold George Chamberlain, London, E.C.4; Ernest John Chesterman, London, N.W.10; Ernest Albert Cooke, Leicester; Captain James Leslie Cruickshank, R.A.O.C., Birmingham; Horace Davenport, Rochester; Captain Gwilym Idwal Parry Davies, R.A.O.C., Liverpool; Alfred William Arthur Dillamore, B.Sc. (Manch.), London, E.C.2; Lieut. Frederick James Dixon, R.A.O.C., Crewe; Colin Smith Donaldson, Bradford; Percy Douglas, London, W.3; Samuel Wilkinson Dronsfield, Oldham; Eric Farron, Carluke, Lanarkshire; Jack Fenton, Abadan, Iran; James Alexander Ferguson, Rangoon, Burma; James Mair Ferguson, Musselburgh, Midlothian; John Forrester, Wellington, N.Z.; John William Gardom, Ripley, Derbyshire; Herbert Arthur Garrett, B.Sc. (*Eng.*) (Lond.), Spondon, Derby; Lawrence Ernest Harris, Leeds; Lt.-Commdr. (E.) Joseph Henry Hopwood, R.N.R., Lowestoft; Ernest Alfred Hounsell, London, W.C.2; Cedric Howarth, London, S.W.1; Douglas Gordon Hunter, London, N.5; John Christopher Hyland, Cuffley, Herts; Edward Philip Jackson, Slough, Bucks; Walter George Jones, Liverpool; Austin Pennington Kewell, Crayford, Kent; John Lambie, St. Albans; Winston Egerton Lees, Kendal, Westmorland; Donald Gordon McDougall, London, S.W.11; Samuel MacEachern, Workington, Cumberland; Alexander McEwan, Luton; Andrew Alexander McEwan, Dumfries; Charles William Niel McGowan, M.A. (Cantab.), Manchester; Ian Richard McKechnie, Harrow, Middx.; Igor Makaroff, B.Sc. (*Eng.*) (Lond.), Manchester; John Simeon Clayton Marshall, London, E.14; Thomas Marshall, Sutton, Surrey; Walter Marshall, Harrow, Middx.; Kenneth Norman Martin, Kidderminster; Samuel Victor Mellor, Bolton; Arthur Mitchell, Halifax; Major Albert John George Mohring, R.A., Romford, Essex; Henry Charles Morgan, West Drayton, Middx.; Arthur Mort, Manchester; James Dickie Morton, B.Sc. (Glas.), Ashington, Northumberland; Graham Francis James Murray, B.Sc. (Lond.), St. Albans; Tom Nuttall, Bolton; James Benzie Peacock, B.Sc. (*Eng.*) (Lond.), Manchester; Leonard Charles Pearch, Maidstone; Major Leonard Henry Pocock, R.A.O.C., Andover, Hants; Henry Quinton, B.Sc. (*Eng.*) (Lond.), Stoke-on-Trent; William Rilett, Abernethy, Perthshire; Ernest Knibb Robertson, Hong Kong; Andrew Eddington Roux, Johannesburg, Transvaal; Hamlet Russell, Birmingham; Stanley Schofield, B.Sc. (*Eng.*) (Lond.), London, S.W.1; William Sephton, Llandudno; Henry Charles Shaw, Birkenhead; Sydney Arthur Slack, Worcester; William Edwin John Smith, Wh.Ex., Oxford; George John Stanfield, Nottingham; Albert Henry Stead, London, N.W.10; Hubert Arthur Stock, Peterborough; Alfred Charles Syrett, London, W.C.1; Edmund Alfred Thake, Enfield, Middx.; Percy Barnes Thomas, Waltham Cross, Herts; William Joseph Thompson, Widnes; Arthur Edward Tyrer, London, S.E.1; George Elsdon Walker, B.Sc. (*Eng.*) (Lond.), Sunderland; Samuel Edmund Walmsley, Gravesend; Major Stanley Lewis Whitby, M.Sc. (*Eng.*) (Lond.), R.A.O.C., Exeter; Donald Sones Woodley, London, N.17; Herbert George Worsley, Bromley Kent; George Leslie Wraige, London, S.E.9.

PERSONAL.

LORD SEMPILL, A.F.C., F.R.Ae.S., has been elected President of the Junior Institution of Engineers for the session 1941-42.

MR. A. S. E. ACKERMANN, B.Sc. (Eng.) (Lond.), F.C.G.I., A.M.Inst.C.E., consulting engineer, has removed from Parliament Mansions, Victoria-street, S.W.1, to 9, Rotherwick-road, Hampstead Garden Suburb, London, N.W.11 (Telephone SPEedwell 4501)

MR. ROBERT GOUDIE has resigned from the board of Messrs. Scottish Machine Tool Corporation, Limited, Glasgow, on account of ill-health.

MR. G. SPENCER SUMMERS, M.P., a director of Messrs. John Summers and Sons, Limited, Hawarden Bridge Steelworks, Shotton, Chester, has been appointed Controller of Area Organisation in the Ministry of Supply.

DR. M. L. BECKER, B.Met., has relinquished his position on the staff of the Metallurgical Department of the National Physical Laboratory on his appointment as chief metallurgist to Messrs. David Brown and Sons (Hudd.), Limited, Huddersfield.

DR. MAURICE COOK, research manager, Messrs. I.C.I. Metals, Limited, Witton, Birmingham, 6, has been elected chairman of the Midland Metallurgical Societies.

MR. DAVID KIRKWOOD, JR., of the Imperial Smelting Corporation, Limited, has been appointed chairman of the Production Advisory Committee (Die Castings).

MR. H. S. F. LANSDOWN, operating manager (central omnibuses), is retiring from the service of the London Passenger Transport Board to-day, September 26, after 46 years' service. He is being succeeded by MR. S. R. GEARY, operating manager (tramways and trolley buses). MR. T. TILSTON, divisional superintendent (southern division), tramways and trolley buses will become operating manager, and MR. P. G. GIBBINS, assistant divisional superintendent (Northern division), will succeed Mr. Tilston as divisional superintendent (Southern division).

MR. CHARLES ALLAN WHEATLEY, B.Sc. (Eng.), of University College, London, has been awarded the Chadwick Gold Medal and Prize. These will be presented at 2.15 p.m., on October 7, by Sir William J. Collins, K.C.V.O., F.R.C.S., chairman of the Chadwick Trustees, at the Royal Society of Tropical Medicine, 26, Portland-place, London, W.1.

MR. T. C. FINLAYSON, M.Sc., M.I.Chem.E., M.I.Gas.E., has been appointed a director of Messrs. Woodall-Duckham Vertical Retort and Oven Construction Company (1920), Limited, Uplands, Epsom-road, Guildford. He has been deputy technical director to the firm since 1932.

ESSENTIAL WORK (GENERAL PROVISIONS) ORDERS, 1941.—The Minister of Labour and National Service is now prepared to consider the scheduling of motor-vehicle general repair shops under the Essential Work (General Provisions) Orders, 1941. Repair shops attached to manufacturers' and operators' establishments have already been brought within the scope of the Orders. The Orders provide that, where an undertaking has been scheduled as engaged on essential work, the permission of a National Service Officer is required before an employee can leave his employment or before he can be discharged for any reason other than serious misconduct. Certain obligations are also laid on employers, one of which is that the terms and conditions of employment shall be not less favourable than those recognised in the industry, which in the case of repair shops means those laid down in the National Agreement concluded between representatives of employers and employees in the repairing industry. Repairers who are members of the Motor Agents Association will receive copies of the Agreement from the Association. Those who are not members of the Association can obtain copies of the Agreement upon application to the appropriate Regional Transport Commissioner of the Ministry of War Transport. The Ministry of Labour and National Service pamphlet E.D.L. 64, which gives a general explanation of the operation of the Essential Work (General Provisions) Orders, 1941, may be obtained from any local office of the Ministry of Labour and National Service. The Ministry of War Transport will be writing to all general repair shops which have been admitted to the Register of Protected Establishments, inviting them to state whether or not they wish to make formal application for scheduling. Repairers whose undertakings are not on the Register of Protected Establishments but who wish their firms to be scheduled under the Essential Work (General Provisions) Orders, 1941, should apply to the appropriate Regional Transport Commissioner as soon as possible, giving the number of employees engaged in the repair of motor vehicles and a short statement of the work upon which the repair shop is normally engaged.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Some concern was felt in the South Wales coal trade during the past week at the prospects for the coal supply position during the coming winter. It was pointed out that, in spite of all the efforts that have been made during recent months, production in the district has failed to show the necessary expansion to enable the collieries to reach target figures set by the Coal Production Council. About a month ago Mr. Arthur Horner, President of the South Wales Miners' Federation estimated that if South Wales was to attain the figure set for it, the coalfield would require an additional 10,000 men. Under the Government scheme for the registration and return of ex-miners to the pits, the number of men now employed in the industry in the district is only about 1 per cent. greater than it was five months ago. Other factors affecting the output are continuing to cause anxiety including absenteeism. It was hoped that the new scheme under negotiation to cure this evil following the abolition of the conditions attaching to the payment of the bonus money would be more successful. There was again a keen demand on the steam-coal market from buyers in the home section. Little new business could be handled, however, because of the well stemmed position of most collieries. Current outputs were almost entirely absorbed by orders already in hand and most producers held sufficient business on their books to provide a steady outlet for almost the whole of their potential outputs for some months to come. The general tone was consequently still very firm. Best large descriptions were moving off steadily on account of standing contracts, and the popular sized classes were only very sparingly available to meet a sustained demand and were firm. Strong conditions ruled for the bituminous small classes which were in strong demand but scarce. Inferior dry steam smalls were still obtainable fairly readily for early delivery. Cokes were in good demand but difficult to secure; patent fuel was steady.

The Iron and Steel Trade.—Very active conditions ruled in all sections of the iron and steel and allied trades of South Wales and Monmouthshire, with the exception of the tin-plate trade which is curtailed by the official restrictions. The demand in all other branches was strong and order books generally were sufficiently well filled to ensure that the works would remain engaged almost to full capacity for some time to come.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Sheffield industrialists have held a private meeting to discuss the labour position in the city's steel and engineering trades. It was a representative meeting, attended by Lord Riverdale and Sir Samuel Osborn and was convened by Mr. T. Goddard Mander, Secretary of the Sheffield and District Engineering Trades' Employers' Association. Though no official statement was issued after the meeting it is understood that concern was expressed at the way in which men are being taken from Sheffield works engaged on the production of vital war products and it is possible that a protest will be sent to the Government. Among the complaints, it is said that key men are being taken from Sheffield war factories and sent to other jobs regardless of the effect on the factories from which they are taken. The position at some works is adversely affected by the posting to pits of examiners, while uncertainty is also caused by the frequent changes in the schedule of reserved occupations. The trade unions are understood to share the employers' anxiety at the amount of skilled labour being taken from the works. Mr. W. Ward, Divisional Organiser of the Amalgamated Engineering Union, states: "We have not been called into discussions with the employers, but we are in agreement with them. It is farcical the way men are being moved about." Councillor F. Lloyd has suggested the setting up of a local tribunal to which employers could appeal for the deferment or cancellation of calling up notices of employees engaged on war work. Intense activity continues in the raw and semi-finished steel branches. The call for all types of raw materials is larger than was the case six months ago. Forward business is difficult to negotiate. In certain classes of steel delay in delivery is inevitable, but, on the whole, consumers cannot complain at the manner in which supplies are coming through. All available tonnage of scrap, whether British or imported, is quickly absorbed. Larger supplies of girders and scrap from buildings damaged by enemy action are becoming available, and a census of all iron railings in Sheffield is being carried out. Business in structural steel is more extensive and supplies are not very plentiful. Rolling mills, forges, press shops, slab and billet mills are all operating at full capacity, and strip and bar mills are turning out record tonnages. The heavy machinery and engineering trades are busy. Export requirements in railway rolling stock and grinding and crushing machinery show a tendency to rise, and a larger volume of business is being done in electrical plant. Electric motors for traction purposes, are on order. Some of these motors are for South America, South Africa, Canada, and Australia. The special-steel making branches are operating at increased capacity, but only a limited amount is being used for the production of ordinary commercial articles.

South Yorkshire Coal Trade.—More examiners are returning to the pits, and there is every prospect that the South Yorkshire coalfield will show an increased production in comparison with the past six months. Export trade is still very restricted. Larger quantities of all types of coal are being sent to iron and steel works, where stocks are being built up. Steam coals are in strong request, and the demand for locomotive fuel has been well maintained. The house coal market is more active, and larger quantities of foundry and furnace cokes are available.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—While the total tonnage output of iron and steel is near the maximum and is fully absorbed, bookings do not exceed the quantities that producers can handle and deliveries for work of national importance are satisfactory. Imports of several commodities have been greatly reduced and in some cases entirely suspended, but North-East Coast manufacturers are dealing successfully with the consequent increased pressure for larger deliveries of their products. The usual buyers are holding off the market to a large extent, realising the impossibility of obtaining much material for ordinary industrial requirements until the demand for Government purposes slackens off.

Cleveland Iron Trade.—Consumers of foundry iron have been able to accumulate moderate stocks and continue to receive ample supplies, mostly from the Midlands. Local brands are still scarce and prospects of an increase in the make are remote. Some expansion of merchant business is reported, but sales are still mainly direct from maker to consumer. The official quotations for Cleveland pig remain at the equivalent of No. 3 quality at 128*s*., delivered within the Tees-side zone.

Basic Iron.—Conditions in the basic-iron branch of trade are unchanged. Occasional small additions to emergency stocks are possible after the large and increasing needs of the makers' own steelworks are covered, but there is still no tonnage for the market and the price remains nominal at 120*s*. 6*d*.

Hematite.—Restrictions in the distribution of hematite are still unavoidable, but the scarcity is somewhat less acute. Delivery licences are granted only for essential needs and the use of substitutes, wherever possible, is increasing. The stabilised values are at the level of No. 1 grade of hematite at 138*s*. 6*d*., delivered to North of England areas.

Foreign Ore.—Cargoes of foreign ore are arriving regularly and are quite sufficient for requirements, except for production of hematite.

Blast-Furnace Coke.—The situation as regards Durham blast-furnace coke, although fairly satisfactory, is not conducive to new business. Sellers have command of large quantities, but have substantial contracts to fulfil and are not desirous of booking further orders. The fixed prices are based on good medium qualities at 36*s*. 9*d*. f.o.r.

Manufactured Iron and Steel.—No uneasiness is felt concerning the supply of semi-finished iron and steel. Imports from America have ceased, but stocks at the re-rolling mills are large and deliveries of local products are increasing. In branches turning out heavy commodities, finished-iron firms are fully employed, but are less busily occupied in departments producing light descriptions of material. The consumption of special-alloy steels is increasing, and the heavy demand for steel strip, tank and boiler plates continues.

Scrap.—Merchants are unable to cope fully with the heavy demand for iron and steel scrap, and another drive to increase the collection of material is now under consideration.

THE LATE MR. H. KINGSFORD HARRIS.—We note with regret the death of Mr. Henry Kingsford Harris, M.A. (Cantab.), which occurred at his home in Madrid-road, Barnes, London, S.W.13, on September 18. Mr. Kingsford Harris, who was 74 years of age, was educated at Trinity College, Cambridge. He was the inventor of the Publicity Telegraph, which enables announcements to be made in large letters by daylight, or with artificial light at night. The system may be controlled locally or from a distance. He was elected an associate member of the Institution of Electrical Engineers in 1918 and was also a Fellow of the Royal Society of Arts.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

SHEFFIELD METALLURGICAL ASSOCIATION.—Saturday, September 27, 3 p.m., Sheffield Metallurgical Club, 198, West-street, Sheffield, 1. Joint Meeting with the *South Yorkshire Section* of THE INSTITUTE OF CHEMISTRY. Discussion on "The Training of the Chemist for Industry."

INSTITUTION OF MECHANICAL ENGINEERS.—*Yorkshire Branch:* Saturday, September 27, 3 p.m., The University, Sheffield. Joint Meeting with THE LEEDS ASSOCIATION OF ENGINEERS and the *Yorkshire Section* of THE INSTITUTION OF PRODUCTION ENGINEERS. General Meeting. Lecture: "Combustion, Detonation and Turbulence in Petrol Engines," by Professor W. T. David. (To be preceded by an Informal Luncheon at The University Staff House, 2, Beech Grove-terrace, Sheffield, at 1.30 p.m.).

WOMEN'S ENGINEERING SOCIETY.—Saturday, September 27, 3.15 p.m., The Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Nineteenth Annual Conference. Presidential Address on "Women in War-time Engineering," by Miss Caroline Haslett.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, October 4, 2.30 p.m., 39, Victoria-street, Westminster, S.W.1. Informal Meeting. "Epidiascopes in General and the J.I.E. Epidiascope in Particular," by Mr. H. J. N. Riddle.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS.—Saturday, October 4, 2.30 p.m., The Royal Victoria Station Hotel, Sheffield. Joint Meeting with THE SHEFFIELD METALLURGICAL ASSOCIATION and THE IRON AND STEEL INSTITUTE. (i) "Examination of a High-Sulphur Free-Cutting Steel Ingot," by Dr. E. Gregory and Mr. J. H. Whiteley. (ii) "The Thermal Relations between Ingot and Mould," by Mr. T. F. Russell. (iii) "The Formation and Properties of Martensite on the Surface of Rope Wire," by Mr. E. M. Trent. (iv) "Note on the Resistance to Furnace Atmospheres of Heat-Resisting Steels," by Mr. A. G. Quarrell. (To be preceded by an informal luncheon at 1 p.m.).

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the Scottish steel trade are practically unaltered. Special high-grade qualities of steel are in great demand, and this is likely to continue indefinitely. The shipyards are all fully occupied and specifications for plates and sections are coming in steadily. Boiler makers are actively employed and the demand for boiler plates is heavy. Good business is being done in structural material and also in steel for the locomotive and wagon-building industries. The black-steel sheet trade is busy, the demand for the thinner gauges being heavy. Steel scrap is still somewhat scarce as smaller lots have been coming in from America, but some improvement is reported with regard to local collections. Prices are unchanged and are as follows:—Boiler plates, 17*l*. 12*s*. 6*d*. per ton; ship plates, 16*l*. 3*s*. per ton; sections, 15*l*. 8*s*. per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l*. 15*s*. per ton; black-steel sheets, No. 24 gauge, 22*l*. 15*s*. per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l*. 2*s*. 6*d*. per ton, all for home delivery.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade makers are meeting a steady demand and the works are busy. Scrap iron is not very plentiful and local authorities are being pressed to get all available material collected. After a quiet spell the re-rollers of steel bars have recently booked some good orders and are now well employed. The stocks of semies now held are ample for all requirements. The following are the current quotations:—Crown bars, 15*l*. 12*s*. 6*d*. per ton; No. 3 bars, 13*l*. 12*s*. 6*d*. per ton; No. 4 bars, 13*l*. 17*s*. 6*d*. per ton; and re-rolled steel bars, 17*l*. 15*s*. per ton, all for home delivery.

Scottish Pig-Iron Trade.—The Scottish pig-iron trade is still active. Although the raw material position is good makers are having to use different kinds of ore in the furnaces, but production is not suffering. To-day's market quotations are as follows:—Hematite, 6*l*. 18*s*. 6*d*. per ton, and basic iron, 6*l*. 0*s*. 6*d*. per ton, both delivered at the steel works; foundry iron, No. 1, 6*l*. 5*s*. 6*d*. per ton, and No. 3, 6*l*. 3*s*. per ton, both on trucks at makers' yards.

TROOP TRAINS ON THE L.M.S.—During the first two years of the war, 14,132 special trains carrying over 4,000,000 members of H.M. Forces and 104,694 tons of baggage have been run by the London Midland and Scottish Railway. This is in addition to the very large numbers of H.M. Forces travelling by ordinary trains.

SCOTCH BOILERS FOR AMERICAN-BUILT BRITISH CARGO STEAMERS.

THE AMERICAN LOCOMOTIVE COMPANY, SCHENECTADY, N.Y., U.S.A.

FIG. 1. GENERAL VIEW OF BOILERS IN SHOP.

FIG. 2. ASSEMBLY OF FURNACES AND COMBUSTION CHAMBERS.

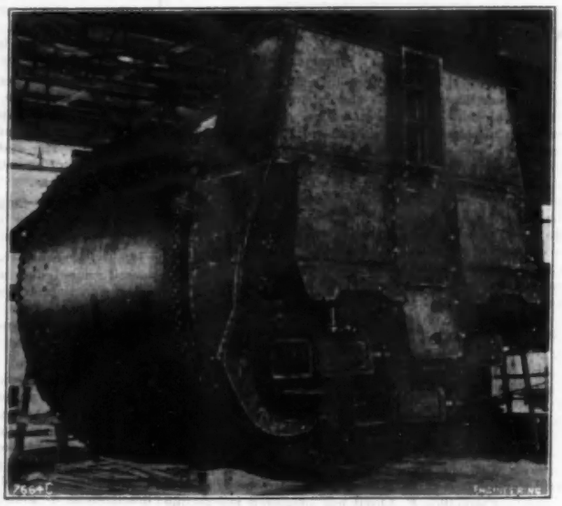


FIG. 3. FRONT VIEW OF BOILER.

BOILERS FOR AMERICAN-BUILT BRITISH STANDARD SHIPS.

SLOWLY—very slowly—a few scattered particulars are being released by the Departments concerned, regarding the 60 standard cargo ships that are being built in the United States to the order of the British Government. The three illustrations on this page show some of the boilers under construction at the works of the American Locomotive Company, Schenectady, N.Y. The main dimensions of the ships, as given out from American official sources, were mentioned on page 87, *ante*, in our article describing the shipyards in which they are being constructed, and it has been announced that they are to be propelled by steam reciprocating engines, supplied with steam from cylindrical boilers; but no details have been disclosed by the Admiralty other than this bare statement. The reasons for the embargo are not self-evident, since the information already published in America, although not officially admitted here to be authentic, is obviously not very far from the facts, and appears unlikely to be of military significance to the enemy.

Meanwhile, although no information at all was permitted at first to be published relating to the machinery, the authorities have relented to the extent of issuing the accompanying photographs; and those who are familiar with the machinery arrangements of cargo steamers may amuse themselves, after the manner of the German savants who are reputed to have built up a complete picture of some prehistoric monster from a single fossilised foot-print, by drawing their own conclusions about the powering of these standard ships. It will be seen that the boilers are of quite moderate size and of conventional design, with three corrugated furnaces (apparently of the Morison type) with separate combustion chambers, and tubular air-heaters. A certain amount of welding appears to be employed in the construction, but otherwise the boilers present no features of any great technical interest. From the American point of view, indeed, they must seem to be decidedly old-fashioned, for American shipbuilders and owners, during recent years, have been much less conservative than British in the adoption of water-tube boilers for mercantile tonnage and have practically abandoned the fitting of cylindrical boilers in new ships. There are sound reasons, of course, for selecting the simplest type of machinery for these vessels, especially in view of the impossibility of finding sufficient of the highly trained personnel that would be needed to operate more elaborate machinery.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

CONTENTS.

	PAGE
Clay and Soil Mechanics (*Illus.*)	241
Literature.—Mechanical Vibrations. Air Navigation. Practical Cost Accounts	243
Cements for Glass Inserts in Electrical Apparatus	245
Bearing Alloy for Use in Sea Water	245
American Society for Testing Materials	246
Horizontal Bending and Straightening Machine (*Illus.*)	246
Electricity Supply in the British Empire	247
Institution Elections	248
Personal	248
Notes from the South-West	249
Notes from South Yorkshire	249
Notes from Cleveland and the Northern Counties	249
Notices of Meetings	249
Notes from the North	249
Boilers for American-Built British Standard Ships (*Illus.*)	250
The Select Committee's Reports	251
Engineers' Earnings	252
Notes	253
The Institute of Metals	254
Letters to the Editor.—Research in Electrical Engineering. The Tide-Generating Forces. Magnesium Production in the United States. Oil and Moisture in Compressed Air. Material Tables for Wire, Bar, Etc. Restrictions of Output	255
Stud Driver-Extractor (*Illus.*)	256
Labour Notes	257
Side-Launching of Submarines (*Illus.*)	258
The Portland Cement Industry of the United States	259
Catalogues	260
"ENGINEERING" Patent Record (*Illus.*)	260

ENGINEERING

FRIDAY, SEPTEMBER 26, 1941.

VOL. 152. No. 3950.

THE SELECT COMMITTEE'S REPORTS.

THE article on "Restrictions of Output," in our issue of August 29, on page 171, referred in passing to the 18th Report of the Select Committee on National Expenditure, for the Parliamentary session 1940-1, containing a summary of the replies of the Government departments to the comments and recommendations of the Committee. Most of these replies, we observed, could be regarded as reasonably satisfactory, while clearly justifying the critical care with which the several investigations had been carried out; but we deferred, *pro tem.*, further discussion of them in order to consider the more topical question of the output of labour in the war industries. The opportunity may now be taken to revert to the 18th Report and its record of the departmental action and comments in respect of some eleven earlier reports in the present session. These cover a wide variety of subjects, but the greater part is concerned with one aspect or another of industrial and constructional activity under the ægis of the war departments, or with the expenditure of public funds directly by the fighting Services on the provision of equipment.

The first report to be commented upon is the second in the 1940-1 series and the sixteenth presented since the Select Committee was appointed in the previous session. It dealt with the acquisition of sites and property by the Balloon Command of the Royal Air Force; commented on the expensive and unsuitable premises that had been taken over in some districts; and criticised the existing arrangements for the settlement of claims by property owners for premises thus requisitioned. The reply from the Air Ministry shows that, at April 1, 1941, there had been 3,461 occupations of sites and premises, that 3,088 claims had been received, and 2,322 had been settled. The average cost of the 1,357 balloon sites covered by settlements was slightly over 9*l.* per annum.

More, important, however, in the extent of its bearing upon industrial conditions was the 3rd Report of 1940-1, dealing with such labour problems as hours of work and dilution; and, although many of the points that it raised, on presentation in December last, have since been met by modifications of practice or by new emergency legislation, the memorandum received in April from the Ministry of Supply may be briefly summarised. On the section of the report dealing with the effects of excessive overtime, the Ministry expressed agreement with the view that three-shift working should be the ultimate aim, and stated that this was already normal in the Government explosives factories and was being extended to the filling factories, though difficulty was found in certain places in obtaining sufficient transport. It was felt, however, that the proposal that the Ministry of Labour should fix the working hours was "not one in which it should be asked to acquiesce," as it might result in a reduction of output. Action had been taken to improve the heating and ventilation of factories; and the processes of dilution, and of training non-skilled labour for work of higher categories, were being successfully pressed forward. The Ministry agreed with the Committee that contracts on a basis of cost plus a percentage should be avoided wherever possible, and that up-to-date costing information should be obtained; and was carrying out "spot costing" investigations in order to determine the best distribution of orders. The more important contractors were being asked also to place at the disposal of the Ministry the costing information that they prepared for their own administrative purposes.

A memorandum prepared by the Treasury, in reply to the Committee's 4th Report (on Government trading in time of war, types of contract, control of costs, etc.) also disclosed substantial agreement with the Committee's views, but expressed doubt as to the necessity for an agreed list of contract terms, which had been recommended as desirable to avoid confusion. On the question of types of contract and methods of costing, the Treasury agreed that the transition from peace to war necessitated the development of alternative methods of controlling contract prices, and that the cheapest production was usually best secured by a fixed-price contract. It was felt, however, that the virtue of a fixed-price contract lay chiefly in confidence that the fixed price was a good price, allowing the contractor a reasonable profit if he executed the work with due care and diligence; and it was the difficulty of feeling that confidence, sometimes experienced by the department and sometimes by the contractor, which led to the development of intermediate forms of contract, with varying emphasis of control as between cost and profit. There must always be a considerable volume of contracting, particularly on repair work and new work of exceptional urgency, where payment on the basis of cost was unavoidable.

The Treasury noted the recommendation that proposals to depart from the rules suggested by the Committee should be subject to special scrutiny, but did not feel that they could be asked to sanction what must necessarily be individual contracts of the supply departments. They proposed, however, to call for a periodic review, in consultation with the departments, of the development of their practice, while pointing out that it was already customary, where novel forms of contract or unusual procedure were contemplated, for these to be brought for discussion before the Treasury Inter-Service Committee. The question of the treatment of overhead costs had been fully examined by the Treasury and the Government accountants in association with representatives of the Federation of British Industries, and the conclusions had been circulated to the members of the Federation. Arrangements for costing had been reviewed on a number of occasions since the war began, and changes had been made which had effected considerable improvements by avoiding overlapping, promoting uniformity of procedure, and accelerating results. Difficulty was felt, however, regarding the Committee's recommendation that lists of contractors should be drawn up, graded in accordance with the quality of their work, as a guide to the Contracts Branch in placing further orders; as, in existing circumstances, they could hardly forgo any productive capacity. As regards credit facilities for small firms, the Treasury stated that they regarded it as important to maintain that working capital should be provided through the ordinary financial machinery, and they

were accelerating Government payments to the utmost, to render this possible. On the question of departmental organisation, which the Committee had criticised, the Treasury stated that the terms of reference of the Contracts Co-ordinating Committee had been revised, to secure greater economy and promote uniformity between departments.

The 5th and 6th Reports dealt, respectively, with the construction of militia camps and the organisation of the Ministry of Agriculture and Fisheries, and the comments upon them, as well as those upon the 11th Report (emergency building schemes, etc.) and the 13th (on a contract for road work), need not be examined in detail. The 7th Report, on the construction of factories, contained some caustic observations on the lack of co-ordination between the various responsible officials, and especially on the absence of any unified control of complete contracts. The visiting sub-committee were also "greatly perturbed at the apparent idleness of the workmen" on one site, and blamed the contractors for inadequate supervision. To these strictures the Ministry of Works and Buildings responded, in a memorandum dated May, 1941, that there was now an officer in complete charge of each large scheme, with definite responsibility for co-ordination and for processing generally; that every effort was being made, in sub-contracting, to utilise local firms to the fullest extent; and that, while supervision was mainly a matter of contractors' staff, the Ministry's control was being strengthened.

The 8th Report dealt with coal shortage and the allied subject of transport conditions, and recommended, *inter alia*, that more drastic steps be taken to release wagons from sidings, etc.; that a comprehensive scheme be planned to create coal stocks to meet the winter needs of 1941-2; that the problem of transferring labour to mining areas should be "tackled resolutely"; that railwaymen and miners should not be called up for service with the armed Forces unless absolutely necessary; and that Government departments should be obliged to estimate their coal requirements quarterly in advance, in areas where supplies are short and needs are expanding. It does not appear that the troubles seen and feared have been entirely obviated yet, but the reply of the Mines Department, dated July, 1941, shows that some attempt has been made to deal with the coal and transport situation. The action taken includes the establishment of a central Wagon Control, which came into operation on March 1 and is reported to have produced good results; the appointment of a committee, representing the Ministry of War Transport, the Mines Department and the Railway Executive Committee, to inquire generally into the coal-wagon position; and steps to develop further the transport of coal by complete trainloads or large blocks of wagons, to reduce the time spent in shunting at intermediate points. The labour problem has been met to some extent by bringing the mining industry under the provisions of an Essential Work Order; but the response to the Minister of Labour's broadcast appeal, for ex-miners to return to the pits, was disappointing. The memorandum sums up the position by stating that "shortage of labour is the kernel of the present coal problem; this shortage is now common to all districts." On the subject of winter coal stocks, it is observed that the original plan was to increase the coal stocks from 15 million tons at the end of March to 39 million tons at the end of October; but "it is clear that the original stocking programme cannot be achieved".

The remaining Reports covered by the departmental replies, and not already mentioned, are the 9th, on the selection, acquisition and construction of aerodromes; and the 10th, devoted mainly to the efficient handling of shipping at home and overseas ports, to the shortage of seagoing engineers, and the acceleration of repair work on ships. The memorandum by the Air Ministry, dealing with the first of these, is extensive and detailed, but calls for little comment here. The 10th Report is discussed in two memoranda, one from the Ministry of War Transport and the other from the Admiralty. Both record that steps have been taken to meet the criticisms of the Committee, and it is common knowledge that there has been, in fact, a marked improvement in the handling of ships.

ENGINEERS' EARNINGS.

In normal times, professors of engineering give considerable time to efforts enabling graduates of their colleges to make a start on a technical career. Frequently they are helped in this activity by appointment boards, which now operate in connection with most universities, while assistance may also be rendered by the professional institution of which any particular graduate may be a student member. The whole of this type of activity is now in a state of suspension. No graduate whose technical attainments make it desirable that he should be employed in some phase of war industry, rather than pass into one of the Services, finds any difficulty in obtaining an appointment. This state of affairs is not likely to endure after the war, except possibly during a period of hurried reconstruction, and in due course engineering graduates will again be faced by the old problem.

The particular branch of engineering to which a young man passes after leaving college is frequently determined by chance: he takes whatever job is offered. In some cases, however, selection is possible. In that case his choice will be largely determined by the course of training which has been followed, and to some extent by the particular interests and enthusiasms of the teaching staff to which he has been subjected. There is also a fashion in these things. At one time, a majority of young engineers were attracted by electrical work, due possibly to the remarkable progress that particular branch of engineering made in the course of some twenty years. More recently, the internal-combustion engine, in its various phases, has proved one of the major attractions. The proportion of graduates entering any particular branch of engineering is necessarily affected by the arrangements which that branch makes to receive it, and the institution of graduate-apprentice courses by some of the large electrical firms enabled them, at one time, to take the pick of the graduates available. Various other branches of engineering have now realised the value of building up their technical staffs by facilitating the entry of selected graduates into their works, and matters are not so one-sided as they were.

Probably few young men to whom a choice between various branches of engineering is offered base their selection on a consideration of which is likely ultimately to provide them with the largest salary, although the immediate emolument offered is often a factor not to be ignored. The late Dr. Rosenhain once told us that, when he was interviewing candidates for a post at the National Physical Laboratory, one young man, asked if research work was of particular interest to him, replied that his real interest was to obtain a job which would furnish him with a salary of 1,000*l.* a year, as soon as possible. It was suggested that in that case he had come to the wrong shop. The point of view of this particular candidate is, we think, unusual. Most young men do not speculate whether electrical or mechanical work is likely ultimately to be more profitable. Even if they did, they generally have no data on which to base a conclusion. The graduate who chooses a particular line of work because of family or other connections, which will ultimately place him in a good position, is, of course, a special case.

It is no one's business to determine whether an engineering graduate, who joins a firm of contractors and specialises on tunnel work, is, on the average, likely ultimately to make more money than one who joins a firm of electrical engineers, or devotes himself to radio transmission. As a result, co-ordinated statistics on the matter are not available. A recent publication by the United States Department of Labor, with one aspect of which we dealt in our issue of August 22, does, however, contain some incidental information on the subject. This publication, entitled *Employment and Earnings in the Engineering Profession, 1929 to 1934*, was prepared at the request of the American Engineering Council in order to determine the effect of the business depression of 1930-1934 on professional engineers. The figures of earnings which it quotes, as they refer to American practice during a special period of stress, have no direct application to this country. It is possible, however, that the relative earning value of different types of activity which is disclosed may have some bearing on British conditions.

The figures in the report were collected and are considered from the point of view of the effect of the depression on engineering earnings, and the relative position occupied by different types of occupation was not quite the same at the beginning of the period studied as at the end. In general terms, however, it was found that, in private employment, mining and metallurgical engineers were paid the highest rates, followed by those engaged in chemical and ceramic engineering, mechanical and industrial engineering, civil engineering and electrical engineering, in that order. In public employment, civil, electrical and mechanical engineers earned less than in private, except for civil engineers engaged on new construction. The particular section of any of the main branches of engineering on which a man was engaged had considerable influence on salary, and it is stated that "engineers engaged in general administration make from half again to twice as much as those engaged in design, construction or operation." Consulting, teaching and sales averaged less than administration, but more than design, construction and operation.

These figures were obtained by means of a questionnaire which brought in 52,589 effective replies. Of these 3,900 were from chemical and ceramic engineers and 19,981 from civil engineers. Whether these two figures fairly represent the proportionate numbers of the two types of engineer in the United States we do not know, but the higher position in the salary scale occupied by the chemical engineers can partly at least be explained by the fact that a smaller proportion of them than of any other class was engaged in public employment. With civil engineers the position was reversed and in most fields earnings in public employment were less than in private industry. An inquiry in this country might disclose the same thing, but in our case public employment usually carries pension rights, which are, in effect, equivalent to an addition to salary. This apparently does not hold in the United States. "The degree of economic security among professional engineers, as evidenced by possession of an employment contract covering some period of time, or by pension privileges, was negligible."

The leading position found to be occupied by chemical engineers is possibly to be explained by the fact that they are engaged in an industry which has greatly extended in recent years, particularly in the plastics branch. As the number of men who have taken a degree in chemical engineering is certainly much smaller than those who have done the same thing in, say, electrical engineering, an expanding industry, competing for the supply available, might tend to raise the standard of salary offered. A condition of this kind, however, would not necessarily be permanent. There is a further factor which may have had an influence on the matter. The proportion of first-degree engineering graduates found in the ranks of ceramic engineers, a branch of the chemical engineers, was, at 77·3 per cent. higher than in any other sphere. The higher standard of education marked by the possession of a degree was, in fact, found to influence earnings.

The inquiry revealed that, although non-graduate engineers had an advantage in the early years, owing to the fact that they were establishing themselves in industry while the graduates were at college, they lost their lead at a time corresponding to five years after graduation. Even two years after graduation the difference in earnings between the two groups was very small. After this initial period the graduates drew ahead, and advancing age showed a considerable advantage in their favour, indicating that, in general, they tended to obtain the better-paid posts. The returns, as a whole, showed wide variations, as might have been expected, and many important positions were occupied by non-graduate engineers. On the average, however, the graduates tended to show the larger earnings in the long run, their emoluments continuing to increase for several years beyond the point of maximum earning capacity of non-graduate engineers. In the case of the latter, the average condition was found to be that their salaries either remained stable, or declined, after the age of 53 years.

NOTES.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE Institution of Mechanical Engineers has for nearly the whole of its existence provided social amenities by the summer meeting, which the wives and relatives of members have the privilege of attending. This year the only social function that it has been possible to arrange was a luncheon, to which ladies were invited, held at Grosvenor House, Park-lane, on Friday, September 19. The success of this function was attested by the large attendance and by the number of distinguished guests supporting the President, Mr. W. A. Stanier. The toast list was naturally a short one, the loyal toast being followed by that of "The Institution of Mechanical Engineers," proposed by the Rt. Hon. A. V. Alexander, M.P., First Lord of the Admiralty. After an assurance that all that it was possible to do to help Russia in the present struggle would be done, Mr. Alexander said that the engineer officers of the Navy, a number of whom were members of the Institution, were responding magnificently to the calls upon them, the average time spent at sea, thanks to the engineers' services, being at least twice what was visualised at the outbreak of war, and four ships had been made to do the work of three times that number. He then cited some specific instances of engineering skill in the Navy, among which was the chase of the Bismarck by H.M. Rodney. This latter vessel when called upon for this service was already long overdue for a refit to her boilers but her speed, by exceptional exertions on the part of her engineers, was worked up to two knots more than she was considered capable of at the best of times. Although there was at the moment a temporary lull in air attack, there was no lull in service for either the Navy or the merchant service. There was, moreover, no lull in the workshops and factories, none in the Air Force, the Army or the civilian defence forces. The President then proposed the toast of "The Guests," preluding it by references to the work the Institution had done and was doing for scientific research and for technical education, and touching upon its ubiquity, its branches being spread over the Empire. After he had briefly alluded to the important services rendered by many of the guests, he extended a particular welcome to His Excellency the United States Ambassador, Mr. John G. Winant. Mr. Winant responded to the toast and in doing so first referred to the visits of American industrialists to this country. The purpose of these visits, he said, was not only to let the people of Britain know what the United States was doing and what it was going to do to help them, but also to find out precisely in what directions help was most desirable. He had deep respect for those in Great Britain who saw in the present difficulties and demands opportunities for self-sacrifice, and who behaved with courage and fortitude. There were three men, however, in whom such qualities were displayed in full measure, namely, the heads of the three fighting Services, Admiral of the Fleet Sir Dudley Pound, General Sir John Dill and Air Chief Marshal Sir Charles Portal.

FIRE PREVENTION ON BUSINESS PREMISES.

The Fire Prevention (Business Premises) (No. 2) Order, which came into operation on September 22, differs on a number of important points from the original Order, which it supersedes; but the general basis remains the same—that is, occupiers of premises in areas to which the Order has been applied by the Regional Commissioner must make adequate arrangements, which may be either voluntary or compulsory in character, and notify them to the appropriate authority. Unless there is a voluntary arrangement, all men between 18 and 60 years of age who are employed on the premises (with certain exemptions) are obliged to perform fire-prevention duties outside working hours, up to a maximum of 48 hours a month. If, however, a man does less than 48 hours' duty under this Order, he may be required, under an amendment of the Compulsory Enrolment Order, to make up the balance in the area in which he lives. An important part of the new Order deals with the provision of sleeping, washing and sanitary facilities, which is now an obligation of the occupier. The provisions for consultation with workpeople have been extended; occupiers must not only consult their workpeople or their representatives, but must supply those representatives with a copy of the arrangements to be notified to the appropriate authority, and a copy must be displayed or otherwise made available for inspection on the premises concerned. The workpeople may make representations themselves to the authority and, in certain cases, there are rights of appeal. The Order establishes subsistence allowances on a scale which ranges from 3*s.* for a continuous period of duty not exceeding 12 hours, outside of working hours, to 6*s.* for a period exceeding 18, but not exceeding 24 hours. The cost of these allowances will be defrayed by the Exchequer. It is stated that "the Government are most anxious that the change of system regarding subsistence allowances shall not be taken as an occasion for departing from arrangements which may have been made . . . for the payment of allowances at higher rates, and they are issuing a joint declaration with representatives of the T.U.C. and of employers' organisations on this subject." Out-of-pocket expenses for travelling, reasonably incurred, will be refunded by occupiers. Finally, it is pointed out that fire-prevention arrangements which were approved under the previous Order will not need, in general, to be renotified under the new Order. An explanatory memorandum on the new Order is being prepared by the Ministry of Home Security and the Scottish Home Department in consultation with the employers' organisations and the T.U.C., and principals of firms, and others concerned, will shortly be able to obtain copies free of charge from the Publications Department, Ministry of Home Security, Horseferry House, Thorney-street, London, S.W.1, or from the Scottish Home Department, St. Andrew's House, Edinburgh. Some of the 19 articles comprised in the Order certainly appear to be in need of explanation; especially, perhaps, the first paragraph of Art. 10, which declares that "It shall be the duty of the occupier of any premises for which arrangements are in force under this Order, to carry out those arrangements, whether or not they were made by him, and notwithstanding that he has been relieved from any obligation to make arrangements under this Order." The operative word, evidently, is "make"; but it is conceivable that some occupiers may misconstrue the clause.

SPARE PARTS FOR MOTOR VEHICLES.

The Ministry of War Transport announce that, in association with the Ministry of Supply, they have given consideration to the report of the Motor-Vehicle Maintenance Advisory Committee, of which Mr. W. E. Rootes was chairman, and appropriate action has already been taken on most of its recommendations. To prevent the hoarding of spare parts, manufacturers and distributors are being asked to ration their customers. Arrangements have been made to ensure that no spares which are in short supply shall be obtainable except for vehicles that are, or are likely to be, immobilised for want of them; and, where hoarded stocks exist, they will be requisitioned. The official announcement adds that "the building of non-standard vehicles out of used parts and spare parts should be stopped"; though it can hardly be that this practice is at all general, and to build a new vehicle solely with spare parts would be a very expensive proceeding in the majority of cases. Following a recommendation by the committee, the two Ministries are co-operating to ensure that all suitable worn parts are returned to the makers for reconditioning, when new or reconditioned parts are issued to vehicle owners. On the labour side, the Ministry of War Transport is taking action to prevent undue depletion of repair-shop staffs, and it is recommended that measures should be taken to promote the training of men, women and boys as motor mechanics, both in Ministry of Labour training centres and within the industry itself. The training department of the Ministry of Labour has started a course of from three to four months, open to men, women and boys. Such a course is not designed to give a specialised training, but should provide the trainees with a background of instruction that is intended to be sufficient to make them useful repair-shop mechanics. The Ministry is also discussing with the industry the development of training in the actual repair shops of the country. The committee called attention to the need to ensure an adequate supply of new spare parts, and also to produce sufficient new commercial vehicles to meet present shortages and to replace old vehicles which may have become uneconomic to run; action is being taken on these lines, but it is pointed out by the Ministry of Supply that the production is bound to be limited, owing to other demands upon the resources of the industry and the country. Other recommendations, on which action is being taken, include the release of Army spare parts for civilian use in cases of vital need; the addition of all spare parts to the list of "essential traffics" on the railways; and measures to accelerate the procedure for claiming compensation for the premises and plant of road-transport undertakings and motor-vehicle repair shops which may suffer damage as a result of enemy action.

FORMATION OF THE NATIONAL DOCK LABOUR CORPORATION, LIMITED.

It may be recalled that, under the terms of the Essential Work Order for the Dock Transport Industry, the National Joint Council for Dock Labour was entrusted with the formation of a company to promote, finance, and administer schemes for the management of labour in ports other than those on Merseyside and on Clydeside, in which the Minister of Transport has become the employer of all dock labour. The company has now been registered under the style of The National Dock Labour Corporation, Limited, and its schemes will embrace the Port of London and the principal ports on the Bristol Channel, the Firth of Forth, the Humber, the Tees, the Tyne and the Wear. The company will have a chairman and a finance member, both of whom are to be appointed by the Minister of Labour and National Service, and the other directors will comprise three representatives of the employers and three representatives of the employees, all of whom will be appointed by the National Joint Council for Dock Labour. According to a model scheme which has been drawn up, a docker will be paid the appropriate rate for a particular job, and piece rates will be introduced as widely as possible. Immediately a job comes to an end the docker is brought automatically into the employment of the Corporation and, subject to certain conditions, will be paid 5*s.* for each of the 11 half-days of the normal working week on which he reports for duty and is not allocated to a job. Two stipulations laid down, however, are, firstly, that a docker must take any suitable work offered, and, secondly, that, if necessary, he may be required to travel to another port. Regular workers will be entitled to an annual holiday of one week, with pay at the rate of 80*s.* for men in the larger ports, and 75*s.* for employees in the smaller ports. Under approved schemes employers will be required to contribute to a national management fund. The amount of the contribution, however, will not exceed one-fourth of their gross wages bill. The fund will be underwritten by the National Exchequer.

CANAL TRANSPORT.

As a result of the report by Mr. Frank Pick on the possibility of making more effective use of canals for inland traffic, the Minister of War Transport has set up a Central Canal Committee under the chairmanship of Colonel J. J. Llewellin, Parliamentary Secretary to the Ministry, to advise on questions of policy and to co-ordinate the work of the six Regional Canal Committees. These six committees have also been reconstituted. It will be their function to organise the effective operation of the canals and the efficient use of craft, to allocate to the canals as much traffic as can be conveniently waterborne, and generally to administer the canal system to the best advantage. Negotiations are stated to be in progress for the establishment of minimum guaranteed wages for canal employees, and a survey of traffic is being carried out with a view to diverting more goods to the canals. This has been done already in the case of coal, with the result that the amount of coal being transported by canal has been increased by 15 per cent.

THE INSTITUTE OF METALS.

The thirty-third annual autumn meeting of the Institute of Metals was held at the offices of the Institute, 4, Grosvenor-gardens, London, S.W.1, on the afternoon of Wednesday, September 17. In the absence abroad of the President, Lieut.-Col. R. M. Preston, D.S.O., the chair was taken by Dr. C. H. Desch, F.R.S., past-president. After the minutes of the previous meeting had been dealt with, the secretary read out the names of members, nominated by the Council, to fill vacancies as officers for the year 1942-43. These nominations comprised, as president, Lieut.-Col. Sir John Greenly, K.C.M.G., C.B.E., M.A.; as vice presidents, Mr. Horace W. Clarke and Mr. H. S. Tasker, B.A.; and as members of Council, Mr. G. Wesley Austin, O.B.E., M.Sc., Mr. W. F. Brazener, and Mr. H. W. G. Hignett. It was stated that the result of the election of the new officers would be announced at the annual general meeting, to be held in London in March, 1942. After the conclusion of the above formal business, four papers were presented for discussion.

Porosity in Tin-Bronze Castings.

The first paper taken was entitled "Causes of Porosity in Tin-Bronze Castings." The authors were Messrs. T. F. Pearson and W. A. Baker, who stated that they had made extensive tests to determine the influence of shrinkage and of dissolved gases on the incidence of porosity in tin bronze. A melting and casting technique, which permitted very close control of all conditions and yielded strictly comparable test results, had been employed. The degree of porosity had been estimated from density measurements and tensile tests had also been made on the castings. It had been found that the bronzes were very prone to dispersed shrinkage unsoundness on account of the long freezing range of the alloys. This unsoundness often appeared as tortuous interdendritic fissures, which had comparatively little effect on density but were very detrimental to mechanical properties. The alloys were also prone to unsoundness resulting from the evolution of hydrogen, water vapour, carbon monoxide and sulphur dioxide, the extent of the gas porosity being greatest from the first-mentioned two causes and very much less marked from the last-mentioned gases. Carbon dioxide and nitrogen were inert to the alloys. Gas porosity generally took the same form as shrinkage unsoundness, except in grossly unsound castings, where the cavities might appear approximately spherical in shape. Hydrogen and oxygen co-existed in molten bronzes and recombined during solidification with a resultant evolution of steam. This "steam unsoundness" could be eliminated largely by oxidation to displace the hydrogen, or alternatively, by deoxidation to remove oxygen or convert it to an inert oxide. The generally accepted practice of melting in slightly oxidising atmospheres, followed by deoxidation before pouring, was thus justified. The evidence indicated, however, that elements having a high affinity for oxygen, such for example as phosphorus, would, if present, hinder the expulsion of reducing gases by oxidation.

Mr. G. L. Bailey, who opened the discussion, pointed out that the authors dealt with only part of more comprehensive investigations which were in progress regarding the actual causes of porosity in tin-bronze castings. They had indicated, however, that it was possible to have in a bronze steam unsoundness of the same type, or due to the same reactions, as that which occurred in copper, as had been shown by Allan some years previously. In other words, oxygen and hydrogen could both co-exist in solution in the molten metal in certain circumstances, and react on solidification. As a result of the authors' work the elimination of hydrogen from bronzes on oxidation could now be applied more successfully and satisfactorily. He inquired whether the authors had any reason to think that Dr. H. Lepp's contention that the elimination of hydrogen increased the solubility of tin in the ordinary cast metal, and therefore reduced the amount of the δ-constituent, was a justifiable one.

Dr. J. H. Watson expressed the view that the paper combined academic research with very essential practical conclusions. The rate of pouring, however, was a good deal slower than was usual in practice, and it seemed to him that if this had been more rapid it might have resulted in there being a smaller difference between the porosity of the sand castings and that of the die castings. Dr. H. O'Neill, who spoke next, stated that railway bronze foundries generally employed large percentages of their own scrap, and, in 1935, the position on the London Midland and Scottish Railway had been reviewed to see whether a strong case could be made for the use of specialised melting operations, such as were associated with the names of E. Scheuer, H. Lepp, and others. No complaints were being received regarding the strength of the castings, but, in 1937, an experiment had been made to determine the range of unsoundness existing at that time. A special pattern was made and sent round to four different foundries, a casting of an 87 : 9 : 2 : 3 copper-tin-zinc-lead alloy being obtained from green-sand moulds on five different days. The experiment had shown that the more crude scrap employed, the lower was the density of the castings, but none of the results was considered to be very bad. If the amount of scrap was varied, the mould shrinkage allowance might have to be adjusted.

Mr. F. S. Yates said that his aim was to produce, under rather difficult conditions, castings in gun-metal and phosphor-bronze having the maximum physical properties and test bars truly representative of those castings. He had soon encountered the two chief difficulties inherent in the material, namely, its susceptibility to shrinkage contraction, leading to the harmful intercrystalline fissures mentioned in the paper, and its susceptibility to gas porosity. Strict laboratory supervision and careful control of melting technique and pouring temperatures were absolutely essential if castings were to meet the specifications laid down. The next speaker, Dr. L. Northcott, thought that the contribution would have been of greater value if it had contained more experimental data on the type of unsoundness, this, in many cases, being recorded merely as "so much voids per cent." Moreover, no information had been given regarding the macrostructure. Further, it would have been interesting if the authors had dealt with one or two larger castings, because those mentioned in the paper were on the small side. In a final brief comment, Dr. Desch stated that it was a little surprising that a discussion of this kind should have been necessary just now. In 1914, he had visited a North-East Coast foundry and had seen castings being produced which were far ahead of the specification both in tensile strength and in elongation, and these results had been obtained simply by taking sufficient care.

Mr. W. A. Baker, in a brief reply to the discussion, said that he could not say, with certainty, in reply to Mr. Bailey, whether the α-δ eutectoid was taken into solution in de-gassed bronze. He informed Dr. Watson that, generally, segregation was more marked in chill castings. The exudations due to gas, moreover, were very marked in chill castings. Commenting on Mr. Yates's remarks, he thought the type of test bar required careful specification. On the question of macrostructure, mentioned by Dr. Northcott, some tests, not reported in the paper, had been made, and the only significant observation was that, if considerable amounts of gas were present, some refinement of the macrostructure occurred, but it was quite small except where the gas porosity was excessive.

Unsoundness in Silicon-Aluminium Alloy Pistons.

The incidence of unsoundness in the skirts of small 12-per cent. silicon-aluminium alloy pistons was investigated under practical conditions by Dr. R. T. Parker, and an account of his research was given in a paper entitled "Unsoundness in Gravity Die-Cast Silicon-Aluminium Alloy Pistons." In presenting the paper Dr. Parker stated that the unsoundness took the form of fine cavities, revealed after machining the surface, in positions remote from the runner and riser. A comparison of atmospheric conditions with the percentage of scrap obtained in the foundry showed only a vague relationship Over periods of some weeks, increases in atmospheric humidity were followed by general increases in the percentage of scrap, while, in several instances, sharp daily variations in humidity were followed by sharp changes in the percentage of scrap. A brief examination of a piston, after diamond machining by independent operators, showed that small cavities might be disclosed or concealed according to the technique adopted. Two experiments, in which pistons were cast—from metal having a high or low gas content—into a die-assembly fitted with thermocouples, demonstrated clearly the effects of variation in the gas content of the metal and in the temperature of the die-assembly. A well-marked relationship between soundness and die-assembly temperature was observed, the hotter assembly giving the better results. With metal of both high and low gas content, pistons of reasonable soundness were obtained at the higher assembly temperatures. At the lower assembly temperatures the metal of low gas content gave pistons of inferior quality containing localised unsoundness; on the other hand, pistons from metal of high gas content contained unsoundness of a finer and more general type, owing to the dispersive effect of the gas present. The relationship between the die-assembly temperatures and the soundness of the pistons pointed to a way of obtaining an immediate improvement in the quality of the castings, although a coincidental improvement in the quality of the metal was also desirable.

Mr. F. A. G. Liddiard, the only speaker in the discussion, said that the factors affecting the identification and distribution of porosity in non-ferrous metal alloys were much more complicated than appeared at first sight. It was unwise to assume that unsoundness could be eliminated, or even improved, by ensuring that the metal was free from gas. Furthermore, most of the evidence regarding porosity in castings had been obtained from density measurements and it was a pity that the author had made no density determinations in his investigation. In a brief reply, Dr. Parker said that while no evidence of gas variation had been furnished as he had not actually measured gas contents, he felt justified, from his knowledge, in referring to high and low gas content in different specimens. His only excuse for not utilising density measurements was that his problem was one of production; his main interest lay in the production of sound piston skirts.

Crystal Structure in Cold-Rolled and Annealed Copper Strip.

The third paper on the agenda dealt with "The Influence of Crystal Structure on the Cold Rolling and Annealing of Copper Strip." It was by Drs. M. Cook and T. Ll. Richards, who stated that they had made a study, by X-ray and microscopic methods, of the effect of progressively increasing cold-rolling reductions and of subsequent annealing on high-conductivity copper strips having four different types of crystal structure. The same twin-fibre textures, however, were ultimately developed with increasing rolling reductions in strips possessing all four types of initial structure. The effect of rolling reductions up to about 50 per cent. and subsequent annealing, was to develop a random orientation of crystals, but a rolling reduction of 25 per cent. was necessary to eliminate from the strip any preferred orientation present before rolling. The twin-fibre textures developed in strip rolled with reductions in excess of about 50 per cent., could either recrystallise independently to form a double-texture structure or could coalesce to form a single-texture structure, depending, in general, on the initial grain-size and the magnitude of the final rolling reduction. In certain circumstances, high final rolling reductions and high final annealing temperatures gave rise to the development of abnormally large crystals.

The only speaker in the discussion, Dr. W. A. Wood, said that he was interested to note that the authors had ascertained, as he himself had found eight or nine years previously, that a reduction of about 50 per cent. was necessary to produce any appreciable amount of selective orientation. From the author's statements, it appeared possible to conclude that there was some relation between the

orientation present in the metal and variations in mechanical properties. In a very brief reply, Dr. Richards said that a careful study of the results given in the paper would show a very definite correlation between the structure as shown by the X-ray photographs, the structure as shown by the microphotographs, and the results of the cupping tests furnished.

Crystal Structures of Rolled Magnesium.

"X-Ray Examination of the Crystal Structures of Rolled Magnesium and a Magnesium Alloy" was the title of the fourth and last paper considered by the meeting. It was by Mr. D. E. Thomas, who, in presenting it, stated that he had examined, by transmitted radiation and by the back-reflection X-ray method, specimens of rolled magnesium, of the magnesium alloy Elektron "AM 503" rolled from cast billets, and of the same alloy rolled from extruded slabs. All these specimens showed orientation of the hexagonal axis approximately normal to the rolling plane, with random distribution round the axis. Recrystallisation and grain growth started at a lower temperature in magnesium than in Elektron and also proceeded further. At any given temperature recrystallisation and grain growth proceeded further in the more severely cold-rolled specimens. There were two speakers in the discussion. The first, Dr. L. Frommer, said that using a slightly different technique, he had done work on a cold-rolled magnesium alloy, and had obtained results absolutely in conformity with these contained in the paper. The second speaker, Dr. T. Ll. Richards, expressed satisfaction that research on orientation was being done in this country. Good work in this field, however, was being carried out by investigators in the United States.

A vote of thanks to the authors of the papers and to the speakers in the discussions brought the meeting to a close.

LETTERS TO THE EDITOR.

RESEARCH IN ELECTRICAL ENGINEERING.

To the Editor of Engineering.

Sir,—Naturally I welcome the leading article on page 211 of your issue of the 12th instant under the above heading, and write only to avoid any misconception arising from the concluding paragraph, on page 212, in which you refer to the financial support of the E.R.A.

It is true that in the early years the financial support was found by the B.E.A.M.A. with the assistance of the C.M.A. in co-operation with the Institution of Electrical Engineers, but for many years recently, in addition to increased financial assistance from manufacturers, the largest contributions have come from electricity power and supply authorities, backed by Government grant. The particular researches which gave rise to your leader, although supported in part since their inception by the above organisations, have in fact been mainly financed in recent years by direct contributions from the Central Electricity Board.

Yours faithfully,
E. B. Wedmore,
Director and Secretary.
The British Electrical and Allied
Industries Research Association,
15, Savoy-street, London, W.C.2.
September 19, 1941.

THE TIDE-GENERATING FORCES.

To the Editor of Engineering.

Sir,—This letter is in reply to two letters commenting upon my article on the tide-generating forces. For convenience I shall use the following references: (A) my article in your issue of May 23, page 414; (B) a letter from J. M. L. in your issue of August 22, on page 154; and (C) a letter from Mr. J. S. Tawresey, in your issue of September 5, on page 195.

In my article I emphasised two principles, (*a*) that only the variations in attractive forces need to be considered, so that the movement of the tide relative to the earth depends upon relative forces; (*b*) that only the tractive force along the earth's surface can operate in tidal movements. Both letters (B) and (C) accept the second principle, but (B) goes astray as to the relative forces and propounds a completely erroneous alternative derivation of the tractive forces. (C) is an admirable exposition of a true alternative mode of deriving the tractive forces. While (B) suggests that (A) is apparently a new one, there is no indication in (C) that the method there given is a well-known one. If Mr. Tawresey's exposition originated with himself then it is highly creditable to him, and I have not seen a better exposition of the mode of treatment adopted by him, but it is not entirely new.

It appears therefore to be worth while to state that there are three well-known ways of deriving the tide-generating forces, as follow: (1) the method given originally by Newton, with its variations as regards details of exposition but not in principle, as is utilised in (A); (2) the derivation from the potential of the forces, as used by Laplace and in most mathematical investigations; and (3) the method which appears to have been first suggested by Professor Davis, of Harvard University, according to Darwin's book on *The Tides*, and which considers the earth-moon system revolving round a common centre of gravity, as is utilised in (C). Mr. Tawresey suggests that the third method may be most acceptable from a purely engineering point of view. That, of course, is a matter of personal opinion, and the method easily lends itself to misconceptions by the unwary. Mathematicians would usually prefer the use of the potential of the forces on account of the elegance of the method and also upon the readiness with which the forces in any given directions may be obtained by differentiations. Further, the equilibrium tide itself is simply related to the potential. I chose the first method because, as I said, it is as simple and direct as any, and calls for the least possible mathematical ability.

Since two of these three methods have now been expounded, it seems desirable to consider the second method, which may be of interest to your readers, and which may help some who have had difficulties with regard to the principle (*a*) referred to above. Let C be the centre of the earth, R the centre of the moon, P a point on the earth's surface. Then the attractive force of the moon on a particle of unit mass at a point whose distance from the moon is z is given by $\frac{K}{z^2}$, where K is a constant as in (A). The total work done by this force in moving the particle from P to an infinite distance is the integral of the force through the distance moved, viz.:—

$$V = \int_{PR}^{\infty} \frac{K}{z^2}\, dz = \frac{K}{PR}.$$

Let A denote the angle P C R, a the radius of the earth, and r the distance C R (the distance between the centres of the earth and moon). Then

$$P R^2 = a^2 + r^2 - 2ar\cos A,$$

so that on expansion in powers of $\frac{r}{a}$ we get

$$V = \frac{K}{r} + \frac{K}{r^2}a\cos A + \frac{K}{r^3}a^2\left(\frac{3}{2}\cos^2 A - \frac{1}{2}\right) + \ldots.$$

The actual force on the particle in any direction y is $\frac{\partial V}{\partial y}$.

Now consider the three terms of V. The first is constant for all positions of P, so that differentiation in any direction gives a zero result. The second term can be written as $\frac{K}{r^2}x$, where $x = a\cos A$ and is thus the co-ordinate in the direction parallel to C O. We then get $\frac{K}{r^2}$ for the contribution of this term to $\frac{\partial V}{\partial x}$, and this is a constant for all positions of P so that this second term of V thus expresses a uniform field of force. Such a uniform field of force cannot cause movement of one particle relative to another, and so cannot cause tides. The third term does not yield components of force which are constant in any direction, and it is this third term which is the main part of the potential of the tide-generating force. If it be differentiated with respect to $-a\,A$, we get the tractive force $= \frac{3}{2}\frac{K\,a}{r^3}\sin 2A$, this being taken in a clockwise direction as in (A).

Now it may resolve some of the difficulties in (B) to see that it was the common force whose potential is represented by the second term in V which was subtracted from the attractive force at P, the reason for which J. M. L. could not understand. If he further considers the exposition in (C) he will note that there are two forces along O P and M P which are first vectorially combined, and that the first of these can be represented by components along O C and C P, but that as the second of these components is vertical to the surface of the earth, then we can combine the force along M P with the component of force along C O. This comes exactly to what was done in (A). If J. M. L. will also consider his own diagram he will note that he has an unbalanced system of forces, for all the forces he pictures will each contribute to drawing the earth and moon together. But as we are not concerned with the force upon the whole earth we must consider each force relative to the average force, which is that proper to a particle at the centre of the earth; this is what I did. Again J. M. L. confuses the issues by arguing from forces to velocities. Surely the proper procedure is to tabulate all the forces and to express them in a diagram. Let him further consider a plane through the poles, and he will see that his arguments are erroneous.

As a matter of fact, the angular velocity of the earth plays no part whatever in the theory of the tide-generating forces, but it affects the period of the tide though not the actual magnitudes or directions of the forces. As has been pointed out, in the exposition (C) the balance of forces is automatically preserved, and this is one of the advantages of the method, but those who fail to understand it generally do so by confusing the centrifugal force due to the revolution of the earth as a whole round the common centre of gravity of earth and moon, with the centrifugal force due to the diurnal revolution of the earth. It is for this reason that I do not use the method for students, as the explanation of the necessity for ignoring the diurnal revolution of the earth is not very easily grasped by some. Mr. Tawresey almost courts this difficulty being raised by making his Fig. 1 to be in the equatorial plane when there is no necessity for any plane to be fixed, except that it must pass through the centres of the earth and moon.

Yours faithfully,
A. T. Doodson.
Liverpool Observatory and Tidal Institute.
September 8, 1941.

To the Editor of Engineering.

Sir,—A few minor corrections are required in the quantitative treatment at the end of Mr. Tawresey's very clear explanation of the origin of these forces, which appeared in your issue of September 5, on page 195. They are possibly misprints.

On page 196, the top line should read:—

$$= E\sin A\left\{1 - \left(\frac{1}{1 - \frac{2a}{R}\cos A}\right)^3\right\}.$$

The second line should read:—

$$= E\sin A\left\{1 - 1 - \frac{3a\cos A}{R}\right\}.$$

The fourth line should read:—

$$F_T = -\frac{3}{2}\frac{a}{R}E\sin 2A,$$

and the final expression for F_T in the eleventh line should read:—

$$F_T = -\frac{3}{2}g\frac{M_M}{M_E}\frac{a^3}{R^3}\sin 2A.$$

This negative sign is important.

In the derivation on page 195, F_T is positive when along the tangent in the direction away from the moon. Thus, when $A < 90$ deg., F_T from the above expression is negative, so that the water tends to move to the right, towards the moon. When $A > 90$ deg., F_T is positive, so that the water tends to move to the

left, away from the moon, on this the remoter hemisphere.

Yours faithfully,
GEORGE S. BOWER.

11, West Bank-avenue,
Duffield-road, Derby.
September 13, 1941.

[NOTE.—It has been also pointed out that on page 195 the sub-denominator in the last formula should be R^2 and not R, and that the tractive force is taken in a clockwise direction by Dr. Doodson, whereas Mr. Tawresey takes it in a counter-clockwise direction, so accounting for the differences in sign between the results.—ED., E.]

MAGNESIUM PRODUCTION IN THE UNITED STATES.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of August 29, on page 170, in an article entitled "Magnesium Production in the United States," the following sentence appears:—"It may be noted that of the 7,363,200 lb. used in the manufacture of structural products, 27 per cent. was lost in the manufacturing process, since magnesium oxidises readily at temperatures above the melting point." This statement implies that melting losses in the production of magnesium-alloy castings are of the order of 27 per cent. This is quite misleading, since it has been possible for many years to melt "Elektron" alloys (of magnesium), with only extremely low melting losses.

In the magnesium works of our associate company, Magnesium Elektron, Limited, there are many large melting units, and these operate with melting losses of the order of 3 per cent. to 4 per cent. Even in the production of small castings and die castings, with satisfactory fluxing technique (achieved by the use of Melrasal flux) melting losses of the order of only 5 per cent. are encountered. These figures apply generally in the foundries of the "Elektron" licensees.

Yours faithfully,
For F. A. HUGHES AND COMPANY, LIMITED,
A. B. LISLE,
Metals Manager.

Swinton,
Near Manchester.
September 18, 1941.

OIL AND MOISTURE IN COMPRESSED AIR.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of September 19, page 236, there is a short note under the title, "Oil and Moisture in Compressed Air," from which it would appear that the firm mentioned have become concerned with the presence of oil and moisture in the air delivered by air compressors. Messrs. Reavell and Company, Limited, of Ipswich, dealt with this problem, and means to overcome the trouble were put into operation quite 20 years ago. I do not think that any reputable air compressor firm would to-day be neglectful to their clients in this important matter. In the old days many firms were experiencing difficulties, especially when using compressed air for delicate work, as for instance spraying spirit varnishes on to furniture, and we showed them that a correctly designed aftercooler coupled to an air receiver in which very simple provisions were made for eliminating the water and oil, entirely solved their problem. It is all to the good that this matter should be brought to the notice of engineers installing compressed air services, since careful design often eliminates trouble and sometimes saves costly modifications to the piping installation, and the subject is dealt with in the new pamphlet of the British Compressed Air Society which is about to be published.

There is one point on which we differ from the firm in question, in that we recommend that the service mains should not fall towards the receiver but in the direction of the air flow. There are many reasons for this, among them:—(1) with efficient aftercooling and moisture separation in the receiver, there should be no free moisture leaving the latter, but if the separation is not efficient then it is better for any moisture in the pipes to be eliminated by means of a trap at selected points in the pipe lines, the moisture being assisted towards these traps by the flow of the air. If, on the other hand, the water flow is in the direction of the receiver, then the air stream retards the flow and there is more chance of the moisture being picked up by the air and so passing into the factory, (2) if, as it should be, the air is free from entrained moisture when it enters the pipes, and yet water is found in the pipe lines, this is due to temperature changes in the mains, caused by diurnal variations of temperature and the possibility that some of the piping is outside the building and subject to varying temperature for this reason. Such moisture should not flow back to the receiver but provision should be made so that it is trapped at points where it is likely to be present.

Yours faithfully,
R. L. QUERTIER.

Reavell and Company, Limited,
47, Victoria Street,
London, S.W.1.
September 24, 1941.

MATERIAL TABLES FOR WIRE, BAR, ETC.

TO THE EDITOR OF ENGINEERING.

SIR,—We thank you for the review of our *Material Tables for Wire, Bar and Drawn or Extruded Sections*, which appeared in your issue of September 12, 1941, on page 207. With reference to the last paragraph, however, in which you state that 73·734 ft. might as well have been set down as 73 ft. 9 in., this would certainly be quite satisfactory, only the idea of keeping all the figures in feet and decimals of a foot makes the tables operative for multiples and divisions of the number off in tens. For example, a part $\frac{11}{16}$ in., 90 off plus 10 per cent. allowance is given as 7·73438 ft. If this were given as 7 ft. 9 in., it would be all right for practical purposes, but would confine that table to 90 off. By keeping the figures in feet and decimals the table can be used for 9, 90, 900, 9,000, 90,000, and so on, off, by just moving the decimal point either to the left or right as the case may be. We trust that this point will now be quite clear to you.

Yours faithfully,
For LAWRENCE BROS., LIMITED.
RICHARD H. QUICK.

North-street,
Wester-super-Mare.
September 18, 1941.

RESTRICTIONS OF OUTPUT.

TO THE EDITOR OF ENGINEERING.

SIR,—The "Labour Notes" that you regularly publish have a special value in that they give the views of both sides, but the leading article on "Restrictions of Output" in your issue of August 29 appears to echo the Government reports and rather to neglect the men's side. As your notes recognise, engineering is not a question merely of technical skill and knowledge; it also involves human factors. War conditions have emphasised that these involve such considerations as love and respect for our neighbour, justice, and adherence to agreements. Is rate-cutting under piecework conditions in accordance with the last? An agreement is entered into for certain payment for a job, and then, because a man by additional effort makes too much money, the agreement is unilaterally broken; in peace time, a recognised evil; under war conditions fatal, as it prevents the best efforts of the nation from being mobilised.

Probably its ill effects can never be wholly exorcised under the present system; something radically different is needed. Is this not to be found in the worker having some share in the control of the industry in which he works? A part in the ownership of the means of production will give the working man and woman an incentive, so lacking at present. It naturally involves responsibility and a share in the management as well as sharing in the rewards. The additional effort and initiative this should call forth cannot but be of benefit both to the worker and the employer, and through this to our country in the present crisis. Naturally the interests of both sides are not altogether complementary; they should both maintain their respective trades organisations.

Employers may object that it is difficult to change a system in war time. They have, however, the example of the numerous co-partnership schemes now in operation. And, as pointed out by Mr. J. Spendan Lewis recently, the head of a firm can still maintain proprietorship, either for himself or by retaining the right to appoint his successor. Probably in war time the share in the profits should be made in cash, rather than shares, leaving the recipient to make his own investment. Savings certificates which are negotiable are an alternative. Output is necessary to win the war, but moral values, though not so apparent, have an even greater influence.

Yours faithfully,
ELSMERE HARRIS, B.Sc., A.M.Inst.C.E.

6, Greenfield-crescent,
Edgbaston, Birmingham, 15.
September 6, 1941.

[Our correspondent appears to fall into the common error of confusing "rate-cutting" (*i.e.*, a deliberate breach of a rate-fixing agreement) with rate revision. Surely he would not maintain that any and every rate, once fixed, should stand in perpetuity, irrespective of changing circumstances or of whether the original rate was justified or not? Universal adherence to any such principle would speedily extinguish piecework entirely, because the piece rates thus stabilised would merely become time rates; and not necessarily enhanced time rates in every case. A piece rate is essentially a temporary bargain, struck in the light of particular circumstances; alterations in those circumstances certainly justify the making of a new rate if the old one is palpably inequitable. It must be remembered that the methods of fixing piece rates vary considerably and are by no means proof against error or even against deliberate "wangling."

There have been many schemes for co-partnership, but, while they provide for the sharing of profits, difficulties are encountered when there are only losses to be shared. We believe that a large proportion of Mr. Harris's supposedly incentiveless working men realise, in actual fact, that a prosperous industry offers the best hope of security of employment and that, without prosperity, the system of control signifies comparatively little.—ED., E.]

STUD DRIVER-EXTRACTOR.

THE tool illustrated in Figs. 1 to 4, opposite, should prove of considerable service in both extracting studs and in driving them. The extraction of a stud is carried out readily enough by means of a nut and locknut when there is room to manipulate the necessary spanner, though the operation is often a tedious one, but in modern practice the time factor is of importance, and studs, due to increase in working pressures, etc., are often crowded together and, in some cases situated in comparatively inaccessible positions. The driver-extractor illustrated is self-gripping and self-releasing and the minimum time is, therefore, occupied in its use. The tool, which has been patented, is made by Messrs. M. Semet and Company, Limited, 14, Palmer-street, London, S.W.1, and the standard range covers studs from $\frac{1}{4}$ in. to $1\frac{1}{4}$ in. in diameter, there being a small difference in detail in the tool for the sizes up to $\frac{7}{16}$ in. in diameter, the type illustrated being that for studs from $\frac{1}{2}\frac{1}{2}$ in. in diameter upwards.

The body of the tool is formed as a sleeve which is slipped over the stud and is finished at the top with a hexagon so that an ordinary spanner can be used as an alternative to the tommy-bar shown, which bar is held in place when in use by a set screw. The sleeve is slotted, as shown in Figs. 1 and 2, and a screw with a knurled head and nut passes through the slot. The purpose of this is to locate the tool in relation to the stud so that the chuck, or gripping device, at the bottom of the sleeve makes contact with the plain part of the stud and there is no risk of damaging the thread. In the smaller pattern the adjustment for different lengths of stud is effected by taking the set pin right down the sleeve to form a stop, a locknut being provided for setting purposes. In this case, the tommy bar is in halves which screw into the hexagonal end and are removable at will. The chuck is the same for both patterns, and its construction will be understood by reference to the cross sections through it given in Figs. 3 and 4. It consists of three rollers, of a special alloy steel, which on their inner periphery make contact with the stud as indicated by the chain-dotted circle, representing the stud, in Fig. 3. On their outer

periphery the rollers are in contact with a recess having a somewhat trefoil-shaped contour. As shown in Fig. 3, the tool can be slipped over the stud and as easily withdrawn but, it will be appreciated, as soon as the tool is rotated in either direction the rollers are forced inwards and grip the stud firmly, the pressure exerted increasing with the amount of torque applied to the tommy-bar or spanner. The rollers are mounted in a cage the flanges of which are slotted as shown in Fig. 4 to provide the necessary freedom of radial movement of the rollers. The cage can be identified in Fig. 2, from which view it will be gathered that it is held in place by a retaining washer which does not need adjustment by the user of the tool.

The body of the tool is made of good quality steel and is case-hardened all over, all other parts, except the rollers, being made of mild steel suitable for their several functions. The workmanship is quite satisfactory and the grip exerted is effective. Provided that filings or other swarf or sticky substances are not allowed to enter the chuck the life of the tool should be practically indefinite and no lubrication is needed. It should be understood, of course, that a separate tool is needed for each size of stud, just in the same way as individual spanners are needed. The standard range covers all normal stud sizes between the diameters mentioned, including, in the smaller tool several British Association diameters, while special diameters such as 0·204 in. and 0·367 in., found in certain aircraft engines, can also be handled. The pitch or type of thread of the stud is immaterial, since the plain part only is gripped. It will thus be obvious that the tool can also be employed to hold spindles, shafts, pins, etc. As an indication of the dimensions of the tool it may be noted that the diameter over the bottom of the body of the smallest size is $\frac{5}{8}$ in. and the overall length of the body is $2\frac{1}{2}$ in., the dimensions allowing for a stud $\frac{1}{2}$ in. in diameter and having a maximum projection from the surface of $1\frac{1}{4}$ in. The weight is about 4 oz. The corresponding figures for the largest size are $3\frac{1}{4}$ in., $7\frac{1}{2}$ in. $1\frac{5}{8}$ in., and $4\frac{3}{4}$ in. with a weight of approximately 9·75 lb.

Fig. 1.

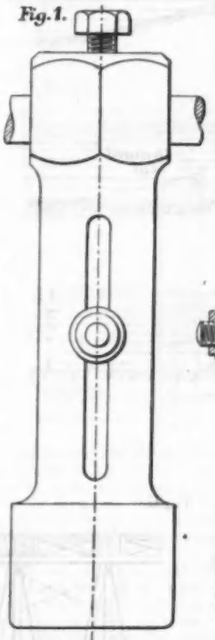


Fig. 2.

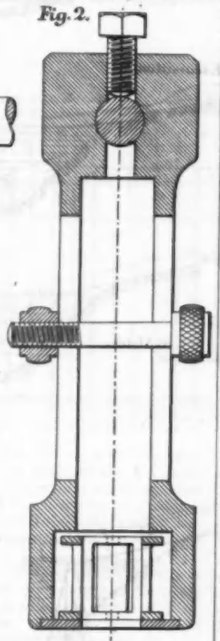
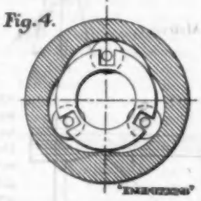


Fig. 3.

Fig. 4.



(7017) "ENGINEERING"

THE SPEED NUT.—Messrs. Simmonds Aerocessories Limited, Great West-road, Brentford, inform us that the range of nuts and fastenings, hitherto sold by them under the title of "Speed Nuts" will henceforth be known as "Spear Nuts." An illustrated description of these nuts and fastenings appeared on page 366 of volume 148 of ENGINEERING (1939).

LABOUR NOTES.

THE following statement was circulated last week by the headquarters of the Trades Union Congress:—"The attention of the T.U.C. has been drawn to a conference on 'What is Holding Up Production' which is to be held shortly in London. As the conference is being convened by the Labour Research Department and will deal with subjects which concern the trade unions, it has been assumed that it has some connection with the T.U.C. or the Labour Party. This is not the case. The Labour Research Department has no such connection and is not in any way recognised by the T.U.C. It has long been the policy of the Trades Union Congress, the Labour Party and the Parliamentary Labour Party that organisations should refrain from supporting the Labour Research Department or attending conferences under its auspices."

The general question raised by the foregoing declaration is discussed in an editorial note in the September issue of the Amalgamated Engineering Union's *Journal*. "Nearly every aspect of industry's war-time organisation has recently been the subject of public criticism," the writer says. "The critics have shown themselves to be of varying degrees of competence. We shall not be unfair to some of them if we describe them as armchair critics. There are others with a good deal of technical knowledge and practical experience whose motives in calling attention to defects and deficiencies in war-time production are not entirely above suspicion. We ourselves suspect the *bona-fides* of people who, a few months ago, were doing their ingenious best to impede production and are now loud in their condemnation of what they call inefficient management. The saboteurs of yesterday are not the heaven-born leaders of 100 per cent. industrial effort to-day, although they may claim to be."

"And," the *Journal* goes on to say, "we feel it necessary to sound a clear note of warning to our own members and to the public and the newspapers that no outside organisation or unofficial body can claim a title to speak for our union. Only the union's properly accredited delegates, appointed according to rule—and acting in accordance with union policy, with the full assent and co-operation of the union executives, can commit the union on any matter whatsoever. To make the point perfectly clear, we will add that the union has not recognised and does not intend to recognise the title of any outside body of any description to define a policy or a course of action for union shop stewards, officials or members."

In August, the home-branch membership of the Amalgamated Engineering Union increased from 500,399 to 509,091 and the Colonial-branch membership from 47,507 to 49,352. During the month the number of members in receipt of sick benefit decreased from 4,328 to 4,303, and the number of superannuated members increased from 13,259 to 13,275. The number of members in receipt of donation benefit decreased from 358 to 230, and the total number of unemployed members from 1,859 to 1,592.

Mr. Tanner states in the September issue of the Amalgamated Engineering Union's *Journal* that for some considerable time, the executive council, in conjunction with representatives of other unions, have been endeavouring to secure a national agreement with the Motor Agents' Association with a view to the stabilisation of the wages and working conditions of motor garage mechanics in public repair workshops. Meetings were held in London on August 13 and 29, and, at the later of the conferences, terms were provisionally agreed to. "As the Motor Agents' Association," Mr. Tanner says, "have never previously been a negotiating body on behalf of their members, the agreement arrived at by their negotiating committee is to be submitted to their managing body for approach. Immediately the agreement is signed it will be circulated to all district secretaries and divisional organisers. It is expected that the agreement will affect between 12,000 and 13,000 garages throughout Great Britain."

The British Employers' Confederation has elected Mr. H. F. Brand President, in succession to Sir Charles Craven who recently vacated that position on becoming Controller of Aircraft Production. Mr. Brand is a past-president of the Confederation.

The cases of all civil, mechanical and electrical engineers now engaged in civilian work, who were under 25 when they registered for military service, and who come within the scope of the University Joint Recruiting Boards, are to be reviewed. This step is being taken in order to make available a number of men qualified for appointment as technical officers in the Forces. Arrangements will be made to submit to the Joint Recruiting Boards the cases of all those who, because they were treated as reserved or had had their calling-up deferred, have not hitherto been interviewed. In making this announcement, the Ministry of Labour and National Service adds that the Committee on Skilled Men in the Services, of which Sir William Beveridge is chairman, has been invited to extend its inquiries to include the commissioned ranks in all three Services.

On September 1 the official cost of living index figure was 99 points above the level of July, 1914, and showed no change as compared with August 1. On September 30, 1939, the figure was 65 points above that of July, 1914. A month earlier it was 55. For food alone the index figure on September 1 was 66 points above the level of July, 1914, compared with 67 points on August 1, the decline being due to decreases in the price of potatoes. Among items other than food the only important change was a slight rise in the average level of prices of clothing and clothing materials.

Following discussions between the National Engineering and Allied Trades Employers Association and the Chemical Workers' Union, agreements have been signed providing for negotiations procedure in the matter of Union members engaged on chemical processes in engineering establishments. These processes include the production and manipulation of chemicals, electro-plating, plastics, accumulators and storage batteries, rubber and ebonite, cellulose, paints and varnishes, and explosives.

The *Review* of the International Labour Office at Montreal states that two measures have recently been adopted in Canada which have for their objects the strengthening of the impartial character of boards of conciliation and investigation and provision for prompt investigation of any threatened dispute before a conciliation board is appointed. The first is in the form of an amendment to the Industrial Disputes Investigation Act and prevents any person from serving on a conciliation board if he is, and, within six months, has been a counsel or paid agent of the parties to the dispute. This is intended to eliminate or reduce any tendency to nominate persons to boards of conciliation who may have any financial or partisan interest in a dispute, and so to ensure a greater measure of impartiality in board procedure in line with the original intention of the Act.

The second measure establishes, by Order in Council, a three-man Industrial Disputes Inquiry Commission. This body will make an immediate preliminary investigation into any threatened dispute. If it is able to effect a settlement, it will in that way avoid the delay and expense of a board of conciliation. If it cannot effect a settlement, it will clarify the major issues and clear the ground for prompt action by a board of conciliation if that proves necessary.

The monthly publication of the International Labour Office also records that early this year the Council of People's Commissars of the U.S.S.R. approved standard rules of employment proposed by the Central Council of Trade Unions with a view to "strengthening socialist labour discipline, promoting systematic organisation in employment, making the fullest and most rational use of the working day, increasing output and ensuring good quality in production." During working hours, it is laid down, workers must not be taken from their work for the purpose of discharging their social duties, and meetings must not be held for the discussion of social questions. Wages may not be paid and vouchers or certificates may not be issued to workers during working hours. If a worker arrives late or leaves before the proper time, he may be transferred to work with lower remuneration for a period of three months or transferred to a lower grade. Absence without good reason will entail compulsory labour for not more than six months and a deduction from wages of not more than 25 per cent.

Workers who arrive late, or leave before the time fixed, will be decreed to be guilty of absence without good reason if the time lost amounts to 20 minutes or more (or even if the time lost is less than 20 minutes in cases where they have come late or left early three times in a month or four times in two consecutive months). Workers who report in a state of drunkenness will also be deemed to be guilty of absence without good reason. Those who leave the undertaking in which they are employed without the permission of the manager will be summoned before the courts and may be sentenced to terms of imprisonment ranging from two to four months.

SIDE LAUNCHING OF SUBMARINES.*

By J. LJUNGGREN.

IN Sweden, most shipbuilding berths are arranged so that the vessels may be launched endwise on one or two sliding ways. This method of launching necessitates, among other things, access to sufficiently wide and deep water outside the berth for the ship to be able to run off the slip for its whole length, with a certain margin, in addition, for safety. At the end of 1939 the Kockums Verkstad works was faced with the problem of building new berths, in a period of about two months, for the construction of submarines, which had to be finished in a comparatively short time. There was no room in the yard for berths with the traditional lengthwise position, and, even if there had been, it would have taken too long to get the berths ready. A scheme was then put forward to use for these submarine berths an area along the yard canal, which is, however, only about 37 m. wide, necessitating sideways launching.

This method had not been previously used in Sweden, and it was generally considered a risky step when the management of the yard decided upon this method of launching submarines; particularly as, in view of the proportions of the site, the construction of the berths had to be different from known precedents; for example, in the American yards on the Great Lakes, where slipways for side launching are familiar. The berths and launching arrangements which have been developed at the Kockums works are described below. A section of the building site before the construction is shown in Fig. 1, herewith.

If the inclination of the launching ways of 1 in 8 to 1 in 12, customary in the American yards, had been adopted, the berths would have had to be built as shown in Fig. 2, with the disadvantage of having to carry the railway siding on removable beams. Eventually a layout was chosen as in Fig 3, also on this page, the launching ways being given the extremely steep slope of 1 in 4, thus causing the minimum encroachment on the canal and the railway siding. Fig. 4 shows a plan of the area, with concrete platforms for the simultaneous construction of two submarines. Both berths were served by a single Diesel-engined crane.

There is nothing to prevent more than two parallel berths being constructed, using the same launching ways. In this way, either all the vessels can be launched at approximately the same time or, as soon as one boat is launched, the other boats under construction can be shifted one stage nearer to the slipway and a new vessel begun at the berth farthest from the water. This naturally has certain disadvantages which specially affect submarines, but these were fully overcome. The construction of the sloping launching ways is shown in Figs. 5, 6 and 7, on this page.

On the timber launching ways, 15 in number and 300 mm. wide, the pressure on the lubricant is much the same as on the yard's longitudinal slipways, that is, about 2 kg. per square centimetre. The building berths themselves were reinforced-concrete rectangular platforms, 10 m. by 75 m. No piling was necessary under the berths, a section of which is shown in Fig. 8, on this page. One great advantage is that a vessel on such a berth can be built with the keel horizontal. On most lengthwise berths a ship is built with a certain inclination, so that all bulkheads, frames, etc., must be erected with the aid of a plumb line or spirit level.

A section of the site with two submarines under construction is given in Fig. 9, opposite, and in Fig. 10 is shown diagrammatically the launching procedure for the submarines built farthest from the canal. After wedging up the vessel and removing the keel blocks, the launching procedure begins with the horizontal "fleeting" through a distance of 26 m. from position I to position II, Fig. 10. The vessel slides on the 15 rails of 300 mm. by 300 mm. timber baulks, which are coated on the sliding surfaces, first with English launching tallow and then with soap.

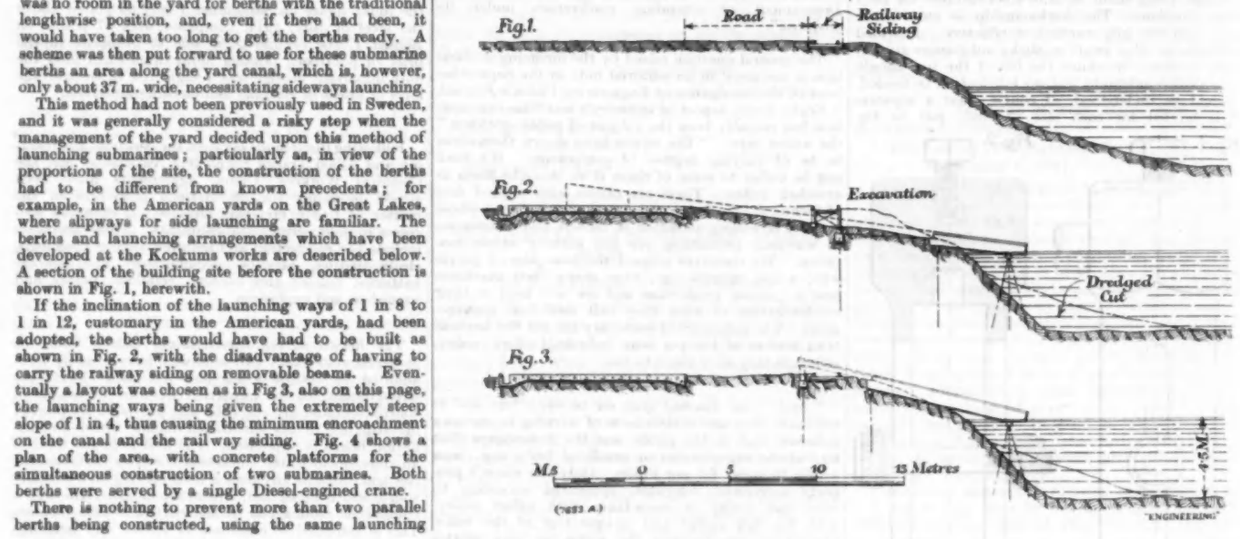
Two hydraulic jacks start the movement, after which two six-sheaved tackles are used, each coupled to its own drum, which is driven by a compressed-air motor. A plan of this arrangement is given in Fig. 11. About 2 hours are required to shift the vessel along the 26-m. stretch. As soon as the vessel comes to position II, Fig. 10, the inclined launching plane, with a slope of 1 in 4, comes into use. The upper and lower parts of the launching cradle (Fig. 12) are connected to a winch during the horizontal motion, and this winch must be released before the vessel can begin to move down the slope. Moreover, the lower part of the cradle must be secured so that it cannot slip back.

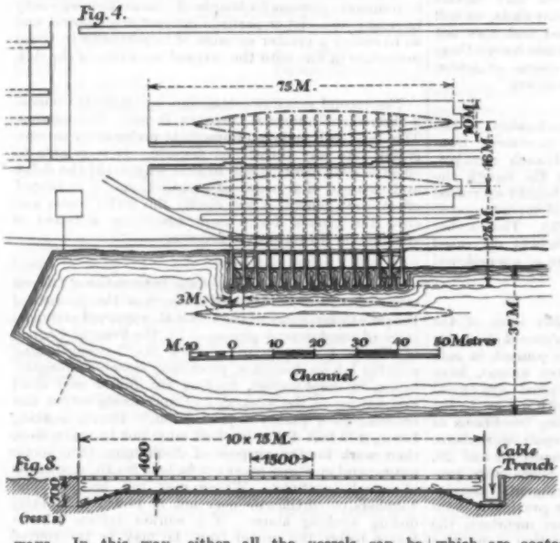
Precautions are specially necessary against the risk that the vessel will run away down the 12-m. length from position II to the water, and severe damage can be caused if it should begin to slip in either direction with one end in front of the other and, because of its obliquity, slide lengthwise off the ways. As the result of experiments with models, it was concluded that the vessel should be released and allowed to travel freely 3½ m. from the end of the berth; this position is marked III in Fig. 10. To control the motion of the vessel on to the inclined plane when traversing from II to III, piles of drag chains are provided, one forward and one aft, of such a weight that extra force must be applied by tackles to move the vessel down the upper part of the slope. Traversing from position II to position III, about 8½ m., takes about three hours.

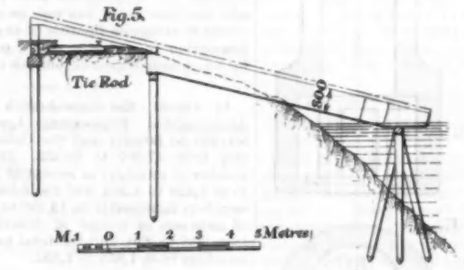
In position III, Fig. 10, the boat is stopped temporarily while the uncoiled chain is made fast to the launching winches, one forward and one aft, these winches being both coupled to a common shaft. As soon as the drags are disconnected, the vessel is ready for the actual launching. At a given signal, the two winches are released simultaneously and the vessel moves rapidly down the ways into the water. The vessel is released 3½ m. up the ways, so that it may attain enough velocity to be thrown sufficiently far out not to crash against the concrete ends of the berth when it rights itself. The launching weight of the submarine is about 340 tons, and the forces operating during the launching are shown in the diagram, Fig. 13, opposite.

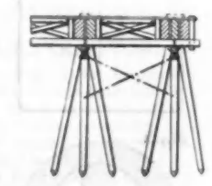
The force acting in each of the drag chains, averaging about 32 tons, must overcome the friction of the drag weights against the ground. In order to determine the friction coefficient, a chain pile of 30 tons weight was dragged along the ground. This experiment gave a friction coefficient of 0·78 at starting and of 0·73 when in motion. The weights calculated on the basis of these values, as applied to the first launch, proved to be reliable for heavier masses, as the chains cut down into the loose soil, giving a resistance coefficient of at least 0·90. Reports in *Marine Engineering* record tests made in America, at Messrs. Ingall's shipyard, with a 120-ton chain pile, where the friction coefficient was found to be 0·90.

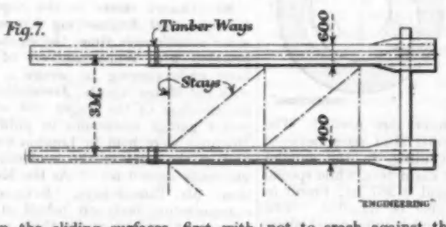
For extra security, anchors were buried in the





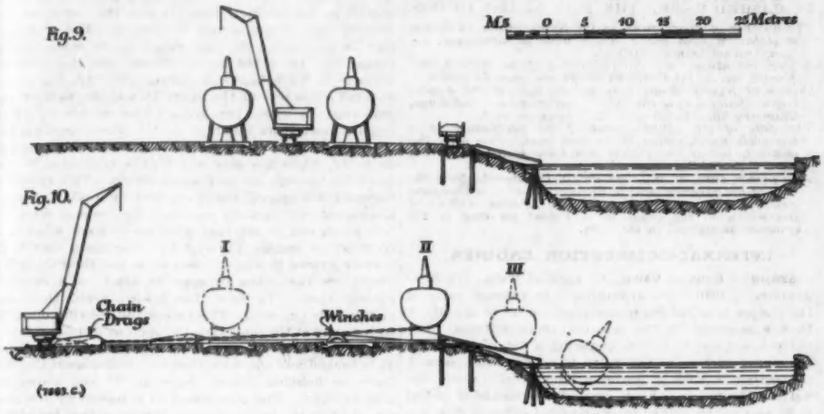


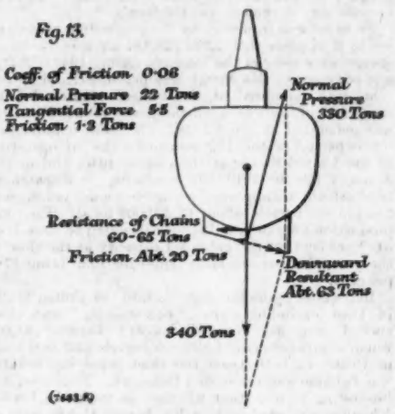


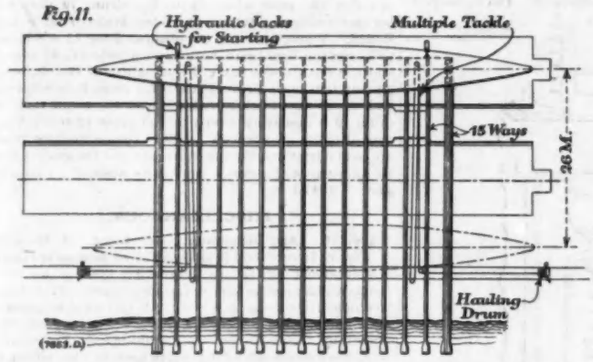


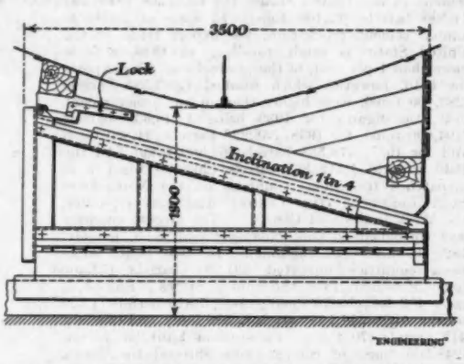
* Paper read before the Swedish Technical Society, Shipbuilding Section, November 23, 1940. From *Teknisk Tidskrift* (Shipbuilding and Aviation), No. 4, April 19, 1941. Abridged.

SIDE LAUNCHING OF SUBMARINES.









ground behind the chain piles and connected to them by means of gin blocks. To measure the launching velocity, a dial was set up with a pointer which travelled over one division a second; a metre scale was painted on the fixed berth, and on the submarine a mark was made so that the relative motions could be filmed during launching.

Unfortunately, the depth of water in the canal was quite small, only 4½ m., while the draught of the vessel to the lower edge of the cradle was about 3·2 m. There was a risk, therefore, that the vessel would touch the bottom. To obtain information on this point, an experiment was carried out with a model boat and canal to a scale of one-fiftieth. It was intended that the model tests should also provide data concerning the heeling angles and the wave formation, and also indicate the distance out into the canal that the boat would reach with different launching velocities. The model was loaded so that the displacement, centre of gravity and moment of inertia corresponded with those of the actual submarine.

In order to measure the depth to which the boat actually dives under the water during launching, two depth meters were made of welded round iron pins fixed in a channel beam placed on edge in the canal. During the launching an angle iron fixed to the cradle sweeps over the pins and bends them, thus providing a measurement of the actual drop.

So far, two submarines have been launched in accordance with this procedure at the Kockums works, and, with a camera operated by clockwork, pictures have been taken at ¼-sec. intervals. The maximum inclination of the boat from the vertical was found to be 36 deg. The final position is well out from the berth. The boat does not float back, so that there is no danger of it being damaged against the berth.

The first launching was very interesting to watch. The final velocity was 3·25 m. per second when the centre line of the boat passed the end of the ways and it took about 2·5 seconds from the release of the trigger until the boat entered the water. The second launching was not in accordance with expectations. From the moment of release, the boat remained for two seconds before beginning to move. Then the after end started. After another second, the forepart began to move and half a second later the boat was seen to be travelling equally fore and aft. Five seconds after release the boat was in the water. The final velocity was 2·9 m. per second, as against 3·25 m. per second in the previous launch.

In seeking an explanation of the reason for the delay after the release, it was calculated that the force in the direction of the slope was about 63 tons, and as no mechanical obstruction could be found, it was clear that friction must have been the cause. This involved a friction coefficient of 0·19, an incredibly high value. The temperature was 10 deg. C. and had varied 5 deg. during the night. The reason appeared to be that the boat had been stationary for about three hours, waiting for the arranged launching time. The two tallow-coated surfaces had adhered and the tallow had to be sheared in launching. Experiments carried out later with a 1,000-kg. test weight showed the same result. When the lubricant was freshly applied, an inclination of 1 in 5 was sufficient for the test weight to move. When the lubricant had been for 23 hours under the same load (2 kg. per square centimetre) as in the launching process, a slope in excess of 1 in 3 was required to start the weight. As, in the actual launches, the berths had an inclination of only 1 in 4, it was evidently an accident that the boat commenced to move at all. In arranging launches, it is necessary to ensure that the boat does not remain at rest for any appreciable time in the final position, but is released immediately after it reaches the launching position. On examination in dock it was found that, in four places, the vessel's hull had small indentations in the strakes, 6 mm. or 7 mm. deep, but as the plating was thin (3 mm. to 6 mm.) the damage was easily repaired.

Side launching, properly carried out, is a method which does not strain the ship's hull, as it avoids the prolonged stressing which occurs when the stern lifts during an endwise launching. In America, the author has seen the method used for 12,000-ton ore-carrying ships with a launching weight of 5,500 tons and a length of 180 m. There is certainly some shock when such a vessel strikes the water, but it is no greater than those encountered at sea in heavy weather.

The side-launching installation at the Kockums yard, consisting of two building berths and one launching berth, cost only about one-third of what a corresponding longitudinal arrangement would have done, and the time occupied in construction amounted to about a quarter of that estimated for one longitudinal berth. The arrangements made have proved satisfactory and, with the experience gained in launching these relatively small vessels, there need be no hesitation in using side-launching for large ships if the conditions are suitable in other respects.

THE PORTLAND CEMENT INDUSTRY OF THE UNITED STATES.

STATISTICS relating to the Portland cement industry of the United States, compiled by the Bureau of Mines, at Washington, show that the quantity of this substance produced in 1940, namely, 130,216,511 barrels* (about 22,130,000 tons) was not only 7 per cent. higher than the output for 1939, but was the largest quantity manufactured since 1930. Nevertheless, the output for 1940 was less by 26 per cent. than that for 1928, which still constitutes the peak year of production. Basing their figures on the quantities of cement dispatched from works into the various States of the Union, aggregating 127,700,563 barrels (21,700,000 tons) the compilers estimate that the annual *per capita* consumption of cement averaged 0·96 barrel (about 3 cwt.) in the whole of the United States in 1940, as compared with 0·94 barrel in 1939. It is pointed out, however, that these are, at best, mere approximations, as they represent only the records of consignments within the country; they do not include imports, which would increase the consumption in States nearest the coast and in certain States adjoining the Canadian border; neither do they make any allowance for a variable but considerable stock of cement at all times in transit, in warehouses, and awaiting use.

From data compiled from reports of the producers it appears that, during 1940, 80·9 per cent. of the Portland cement dispatched from the works was moved by railway, 15·6 per cent. by motor lorry and 2·2 per cent. by boat (with regard to the remaining 1·3 per cent. the method of carriage is not stated). Furthermore, 25·6 per cent. of the cement was dispatched loose in bulk; 42·4 per cent. was packed in paper bags; 31·9 per cent. in cloth bags; and 0·1 per cent. in other containers, including steel drums and iron and wooden barrels. Other interesting statistics given relate to the quantity of fuel consumed in the production of the 130,216,511 barrels (22,130,000 tons) of finished cement during 1940. These statistics, which are derived from data supplied by the cement producers, supplemented by a few estimates made by the Bureau of Mines, show that the consumption of coal at cement works totalled 5,633,156 short tons; of oil, 2,424,976 barrels (each of 42 U.S. gallons);

* The unit of measure employed, throughout the statistics, is the barrel of 376 lb.

and of natural gas, 41,948,699,007 cub. ft. The three principal States utilising natural gas as fuel were, in order of importance, Texas, California, and Kansas, and the principal State using petroleum in the manufacture of cement was California.

From returns furnished by the proprietors of cement works it appears that 2,971,328,181 kWh of electrical energy were used in the industry during 1940. Fifty-one per cent. of this energy was purchased and 49 per cent. was generated at the cement plants. In the case of 27 of the works, all the power required in 1940 was generated at the plants. The total manufacturing capacity of the 152 cement works, in operation in the United States at the end of 1940, and of the 8 works idle in 1940 but producing or dispatching from stock within the seven previous years, was 254,145,000 barrels (about 43,200,000 tons). The total production for the year 1940 is calculated to have been 51·2 per cent. of the indicated capacity at the close of the year, the corresponding figure for 1939 being 47·7 per cent.

Imports of hydraulic cements into the United States in 1940 (excluding white, "non-staining" and other special cements) totalled 535,619 barrels (91,000 tons), compared with 1,890,970 barrels (321,000 tons) in 1939. In both years the chief supplying country was Belgium and the second Denmark. Moreover, it is interesting to note that whereas, in 1939, the United Kingdom exported only 8,405 barrels (1,400 tons) of cement to the United States, the total for 1940 was 71,596 barrels (12,100 tons). In spite of its large annual cement production, the export trade of the United States is small, totalling, in 1940, a little more than 1 per cent. of the production. The exports for 1940, however, which totalled 1,667,595 barrels (283,400 tons), were higher than in any other recent year, the figures for 1939 being 1,146,339 barrels (194,800 tons), for 1938, 558,226 barrels (94,800 tons) and for 1937, 378,554 barrels (64,300 tons). Of the 1940 exports 1,212,909 barrels (206,100 tons) were dispatched to various countries on the North-American Continent, the Central American republics, the West Indies and Canada. The largest quantity was consigned to the Panama Canal zone, namely, 482,849 barrels (82,000 tons). In 1940, South American countries imported 431,904 barrels (73,400 tons) of cement from the United States; Europe, a mere 452 barrels (76 tons); Asia, 7,810 barrels (1,320 tons); Africa, 14,108 barrels (2,390 tons), and Oceania, 412 barrels (70 tons). In addition 1,461,940 barrels (248,500 tons) of cement were shipped to Alaska, Hawaii, Puerto Rico and other outlying territories of the United States.

CATALOGUES.

Machine-Tool Lubricants.—In a leaflet received from Messrs. William Asquith, Limited, Halifax, the use of "Asquiline" for lubricating the various machines built by them is recommended.

Spray Painting Guns.—Messrs. B.E.N. Patents, Limited, High Wycombe, Bucks., have sent us a folder which gives particulars of the various spray guns made by them to obtain the best results in spray painting.

Sheet-Metal Working Machines.—We have received from Messrs. F. J. Edwards, Limited, 358-361, Euston-road, London, N.W.1, a folder illustrating and describing new and second-hand presses, shearing and folding machines for sheet-metal work, of which, it is stated, they can give prompt delivery.

Air-Treatment Plant for the Textile Industry.—We have received from Messrs. Davidson and Company, Limited, Sirocco Engineering Works, Belfast, a copy of their publication No. SF346, describing the uses of "Sirocco" fixed and portable plant for air-conditioning, dust removal, heating, vapour absorption, yarn drying, and other purposes.

REGULATIONS FOR EXPORTS TO BRITISH WEST INDIES.—The Commissioners of Customs and Excise give notice that the pre-war Customs procedure will in future apply to goods for which an export licence is not required, exported to the British West Indies, provided that the proper Customs export entry contains, in addition to the normal requirement, the name and address of both the consignor and consignee of the goods. Exporters and others concerned should note that these colonies and, in addition, British Guiana and British Honduras, will not in future permit transhipment or re-export, to countries to which Regulation 5B of the Defence (Finance) Regulations applies, of goods shipped from the United Kingdom, unless evidence is produced to them that the form C.D.3 has been lodged at the port of exportation in this country. Where such evidence is required an extra copy of page 1 of the form should be presented to the Customs for certification before shipment and forwarded to the local agent in the Colony. Arrangements by cable may be authorised in exceptional circumstances.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

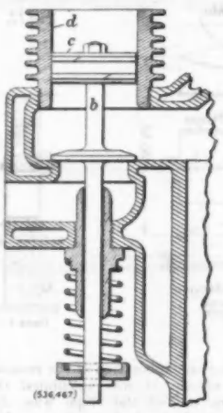
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

INTERNAL-COMBUSTION ENGINES.

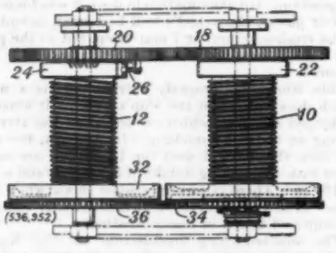
536,467. Exhaust Valve. G. Vigo, of Malta. (1 *Fig.*) January 5, 1940.—The invention is an exhaust valve of the poppet type, which requires less power to operate it than is required by the present normal pattern. The valve has a flat underside engaging a flat seating. On the upper surface of the valve is an extension stem *b* connecting it with a piston *c* immediately above the valve. The piston is made gas-tight by means of piston rings and works within an open-ended cylinder *d* in the upper wall of the combustion chamber. The cylinder is



a separate part bolted on to the head of the combustion chamber for ease of removal in order to obtain access to the exhaust valve. The diameter of the valve should be equal to the diameter of the piston *c* and must remain constant even after grinding in. For this reason the valve has a flat seating surface. By this arrangement the pressure acting on the underside of the piston *c* is equal to the pressure acting on the upper surface of the valve, and the power required to open the valve need only be slightly greater than is necessary to overcome the pressure exerted by the valve spring. (*Accepted May* 15, 1941.)

LIFTING AND HAULING APPLIANCES.

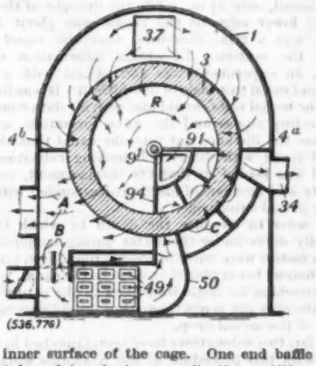
536,952. Grab Cranes. Priestman Brothers, Limited, of Hull, and A. E. Franklin, of Hull. (3 *Figs.*) December 1, 1939.—The grab crane is of the kind having two winch drums, one for the hoisting and closing rope and the other for the opening and holding rope. The hoisting and closing drum 10 and the opening drum 12 are free to rotate on their respective spindles. The two spindles



have inter-meshing gear wheels 18, 20 keyed to them, the gear wheel 18 on the hoisting drum spindle being larger than the gear wheel 20, and being driven by a motor. Each gear wheel is connected to its drum by a friction clutch which is controlled by the crane driver to hoist or lower the grab and open or close it. The gear wheels 18, 20 are unequal in diameter so as to ensure that the opening rope wound on the drum 12 is kept taut when the grab is being hoisted in the closed position. This is rendered possible by the arrangement that, when the manual control of the clutch 24 is released, a spring 26 maintains light pressure between the clutch band and the associated drum. To open the grab, a brake 32 is applied to the opening drum 12 and the clutch on the hoisting and closing drum is released. The grab can then be lowered in the open condition by releasing the brake 32. To avoid the tendency for the hoisting drum 10 to lag behind the opening drum 12, due to the unequal diameters of the gears 18 and 20, so that the grab tends to close, two further gear wheels 34, 36 of equal diameter are mounted on the drum spindles, the gear wheel 36 being fixed permanently to the opening drum 12, while the gear wheel 34 is connected to the drum 10 through an additional clutch. This clutch is normally disengaged, but is engaged by a relay drum of known pattern normally rotating with the gear wheel 34 but which can be arrested by a brake band when it is required to engage the clutch. The main clutch 22 is also operated by a relay brake band, and these two relay bands are connected to opposite arms on a common control shaft. To hoist the loaded grab, the main clutch 22 is engaged. This causes the hoisting drum 10 to turn and at the same time the opening drum is rotated. To open the grab the motor is stopped, the opening drum 12 is braked and the main clutch 22 is disengaged. This frees the hoisting and closing drum 10 and allows the grab to open. The gear wheel 34 is locked by the gear wheel 36 on the opening drum spindle so that the clutch coupling the gear wheel 34 to the drum 10 does not become engaged although its relay brake band is tensioned. When, however, the opening drum 12 is released to lower the open grab both hear wheels 34, 36 rotate, and the relay brake band of the additional clutch, being already tensioned, prevents the relay drum from rotating, and causes the clutch to engage, with the result that the drum 10 is positively driven by the drum 12 through the pair of equal gear wheels 34, 36. Hence the two ropes are paid out at exactly the same rate and the grab cannot be unintentionally closed during its descent. (*Accepted June* 3, 1941.)

MISCELLANEOUS.

536,776. Air Dehydrator. W. Laird, of Hanwell. (8 *Figs.*) December 13, 1939.—The apparatus is especially intended for use in ventilating systems for store rooms which must be kept dry, such as ammunition stores. The dehydrating agent is silica gel, activated alumina or activated carbon, and the air-drying and gel-regenerating operations are continuous and simultaneous. The casing 1 is divided horizontally by partitions 4*a*, 4*b*, which lie in the horizontal plane containing the axis of the stationary shaft on which a cage of silica gel 3 rotates in the direction of the arrow R. Moist air is admitted to the upper part of the casing through the moist air inlet 37 and passes through the zone of the gel wall in the upper half of the cage into its interior. The inner baffle 91 is in the form of a quadrant keyed to the shaft and carrying four radial baffles, each with a working clearance



of the inner surface of the cage. One end baffle 91 is horizontal, and terminates opposite the partition 4*a* in the casing, while the other end baffle 94 is vertical. The dehydrated air within the cage is withdrawn by a main extractor fan through that part of the gel wall which lies between the baffle 94 and the partition 4*b*, the bulk of the air A passing through the main outlet to a cooler for delivery to the chamber to be ventilated. A controllable portion of the dehydrated air B is by-passed through a damper and then flows through a battery of air heaters 49, at the outlet end of which a curved baffle 50 directs the hot air upwards towards the cage. The by-passed air is sucked by a subsidiary fan through the heater battery 49 and flows in a sinuous path C through the quadrant of gel which lies between the baffles 91 and 94. The hot dry air from the heater battery 49 thus traverses the loaded gel six times, vaporising the absorbed moisture and carrying it away to the outlet 34. The action is thus continuous and automatic, ensuring a constant supply of dry air. (*Accepted May* 27, 1941.)